Idaho
National
Engineering
Laboratory

Managed
by the U.S.
Department
of Energy

EGG-TMI-7376

INFORMAL REPORT

TMI-2 RADIATION MONITOR DATA REPORT

R. D. McCormick

EG&G Idaho

Work performed under
DOE Contract
No. DE-AC07-76ID01570

EGG-TMI-7376

TMI-2 RADIATION MONITOR DATA REPORT

R. D. McCormick

Published September 1986

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-76ID01570

CONTENTS

FIGURES

CONTENTS (Contd)

TABLES

ABSTRACT

This is a report on the quality and uncertainty of some of the Health Physics Radiation Monitor data recorded during the TMI-2 accident. The reported data consists of 28 out of a total of 65 channels recorded and were selected mainly through analyst's requests. The radiation rates on all channels were concluded to be trend data and have no attached uncertainties. The time-bases of the recordings were studied in great detail and were categorized as qualified data with corresponding uncertainties attached. All the data reported herein is also contained in the TMI-2 Data Base under the indicated identifiers. Plots of all data are contained in the Appendix.

TMI-2 RADIATION MONITOR DATA REPORT

INTRODUCTION

This report is concerned with health physics radiation monitor data which were recorded during and after the TMI-2 accident. The radiation detectors were located throughout the TMI-2 complex and measured direct gamma radiation as well as radioactive particulates, iodine and gases.

The purpose of this report is to provide background information on the radiation monitor data which are being put into the TMI-2 Data Base. The information given here indicates where the data orginated and how it was corrected to its final state. It specifies the data identifiers, qualification category and the associated uncertainty. In addition, descriptions are given of the instruments, along with details of how the data were digitized and corrected. Zero time for all data was set at the turbine trip time of 04:00:37.

The data reported here were digitized from photocopies of the original multipoint stripchart recordings. Most of these data were selected for presentation because they were of interest to analysts, while the rest of the data were included simply because it was expedient to do so. Some data in this report have been presented in the NSAC-80-1 and NSAC-28 documents.[1,2]

MEASUREMENT CHANNELS

Each of the radiation monitors consisted of a number of instrument components connected together to form a measurement channel. The radiation monitors as a whole were grouped according to their measurement type: airborne, area, or process. Of a total of 65 measurement channels recorded at TMI-2, 28 channels have been digitized and are reported herein.

Area Monitors

The purpose of the area monitors was to detect gross gamma radiation in specific sectors within the reactor facility buildings. The area monitors of concern here were built around a Geiger-Muller (G-M) tube gamma detector (Victoreen Model 857-2). Each detector was self-contained in that it contained the G-M tube, power supplies, and signal conditioning electronics including anti-jamming circuitry. All the area monitors had a local and remote readout meter, and were connected to a stripchart recorder. Figure 1 shows a block diagram of a typical area monitor. All area monitors had a range from 0.1 mR per hour to 10^4 mR per hour and were recorded on semi-log stripchart paper.

Area monitor data were recorded on two stripchart recorders, HP-UR-1901 and HP-UR-1902. This report covers four channels of data out of a total of 21. These four channels were the only ones of interest at this time.

Air Monitors

Air monitors fall into three different categories depending on their function: air particulates, vapors and gases. Most of the air monitor stations providing data for this report measured particulates, vapors and gases. Only particulate and gaseous data are reported herein since that was of major interest.

Figure 2 shows a block diagram of a typical air monitoring station. It can be seen that air is continually drawn through the particulate monitor then through the iodine monitor and finally the gaseous monitor. All monitors are in enclosures.

The particulate monitor was the moving filter type using a Victoreen model 843-20A detector. This detector consisted of a beta sensitive plastic scintillation crystal mounted on a photomultiplier tube. The detector was shielded and used a preamplifier.

The iodine monitor used a charcoal filter and a Victoreen model 843-30 detector. This detector used a NaI gamma sensitive scintillation crystal and a photomultiplier tube.

The gas monitor used a Victoreen model 843-20 detector. This detector consisted of a beta sensitive plastic scintillation crystal mounted on a photomultiplier tube. This device was mounted in a shielded enclosure through which the gas was pumped.

FIGURE 1

TYPICAL AREA RADIATION MONITOR BLOCK DIAGRAM

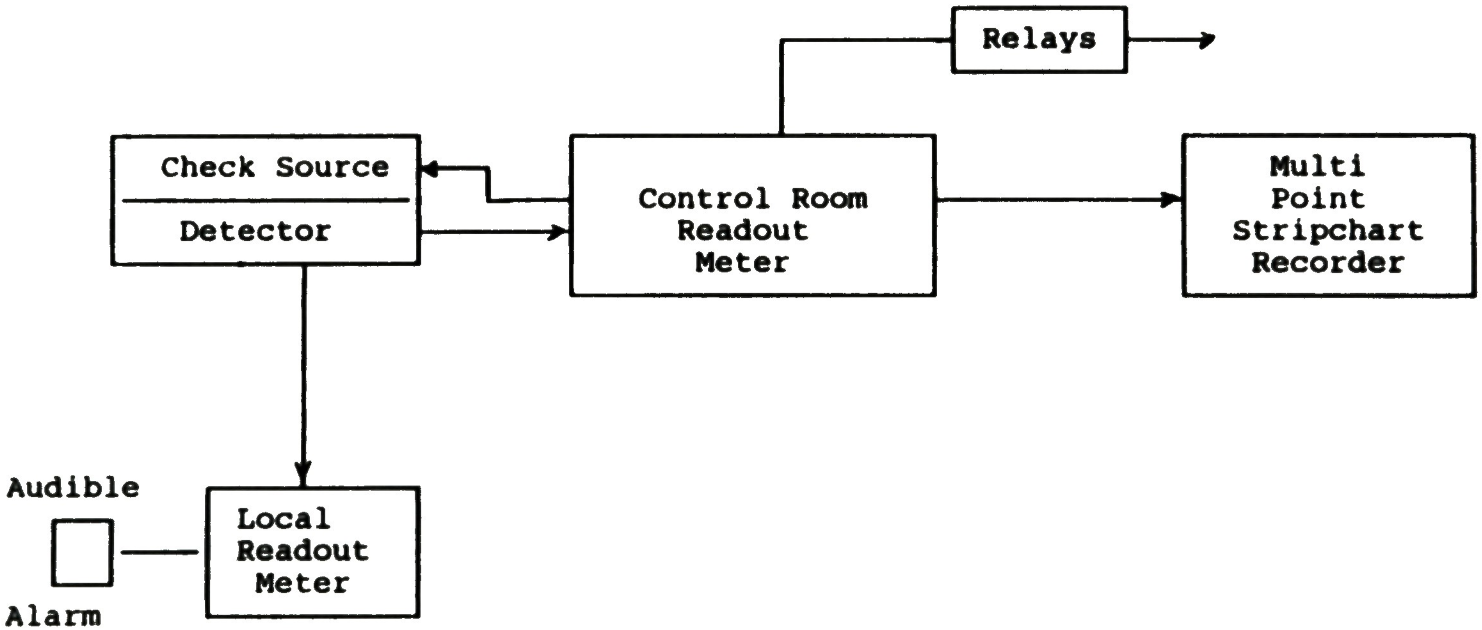
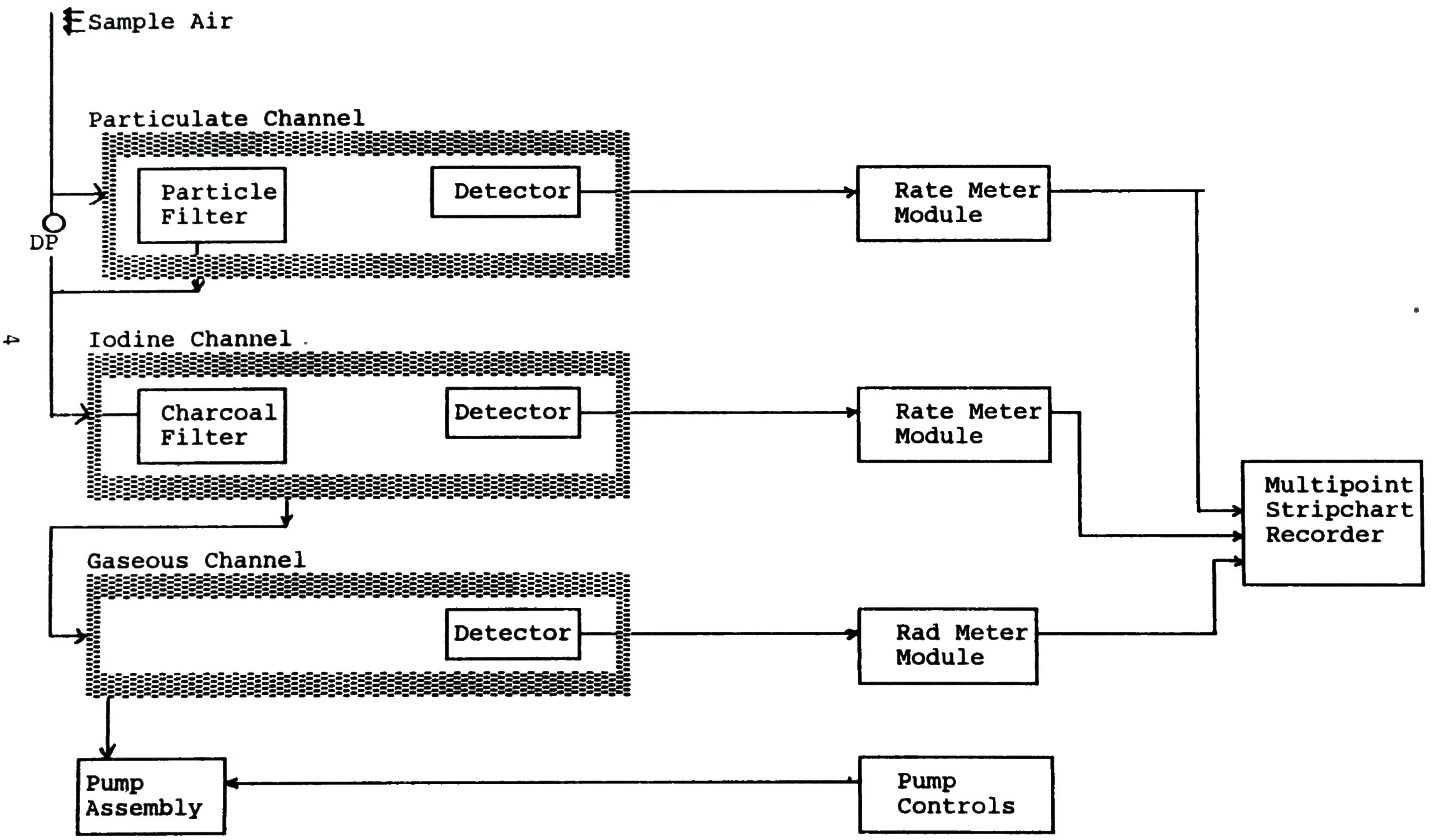


FIGURE 2

TYPICAL AIRBORNE RADIATION MONITOR STATION
BLOCK DIAGRAM



Process Liquid Monitors

The process monitors measured the radioactivity in various water systems in the facility. Recorder HP-UR-3264 contained all the process measurement data. Figure 3 shows a block diagram of a typical process monitor channel. These were mounted off-line so that water samples could be pumped into them when a measurement was to be taken. The monitor consisted of a detector, ratemeter and a pump. The detector (containing the preamplifier) was a Victoreen model 834-30 which used a NaI scintillator crystal and photo-multiplier tube. The detector was designed to measure gross gamma radiation between 80 Kev and 2 Mev. When this detector is used in conjunction with a single channel analyzer, specific gamma energy pulses can be measured. The failed fuel monitor (primary coolant letdown) was the only one to use the single channel analyzer.

Multipoint Recorders

There were six multipoint recorders used with the TMI-2 radiation monitors. These were basically the same recorder except for differences in print frequency, and number of data channels recorded. The recorder used was an Esterline Model E1124E which could continuously measure, indicate, and record the analog signal from any sensing element which produced an equivalent DC signal within the measurement range of the instrument.

The Model E1124E multipoint was essentially a potentiometric measuring and recording instrument capable of making a printed record of up to 24 inputs. Each input signal was sequentially selected and applied to the measuring circuit by a motor-driven switching system. The printing system recorded the measured variables in a standard presentation form of a dot and a number, with the dot representing the actual value of the measured variable and the number indicating the selected point (station). Although the basic design was for 24 points (channels) a fewer number-of-points could be accommodated. Recorders with for 8, 10, 12, 16, 18, and 20 channels were available.

The recorder also allowed the operator to change the paper speed and frequency at which the printer was actuated. A prescribed point number-color existed on all recorders and is shown in Table 1. Five recorders followed the sequence as shown, but HP-UR-3236 started with point number 1 on the brown.

Figure 4 shows a functional block diagram of the multipoint recorder used here.

FIGURE 3

TYPICAL PROCESS MONITOR BLOCK DIAGRAM

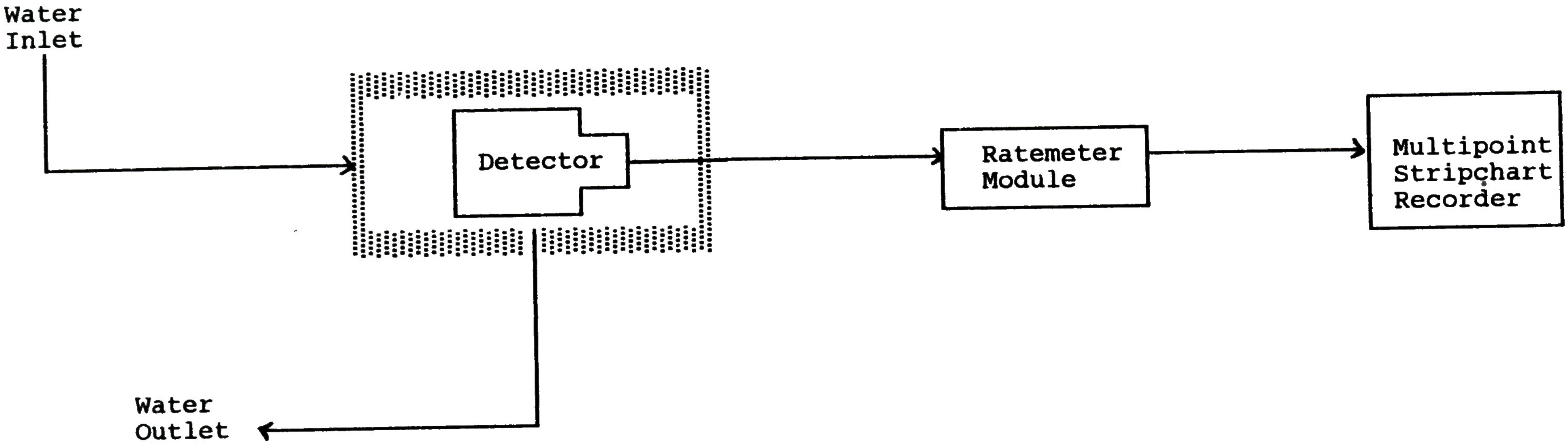


TABLE 1

RECORDER POINT VERSUS COLOR

Point No.	Color
1	Red
2	Green
3	Blue
4	Black
5	Purple
6	Brown
Repeat cycle	Repeat cycle

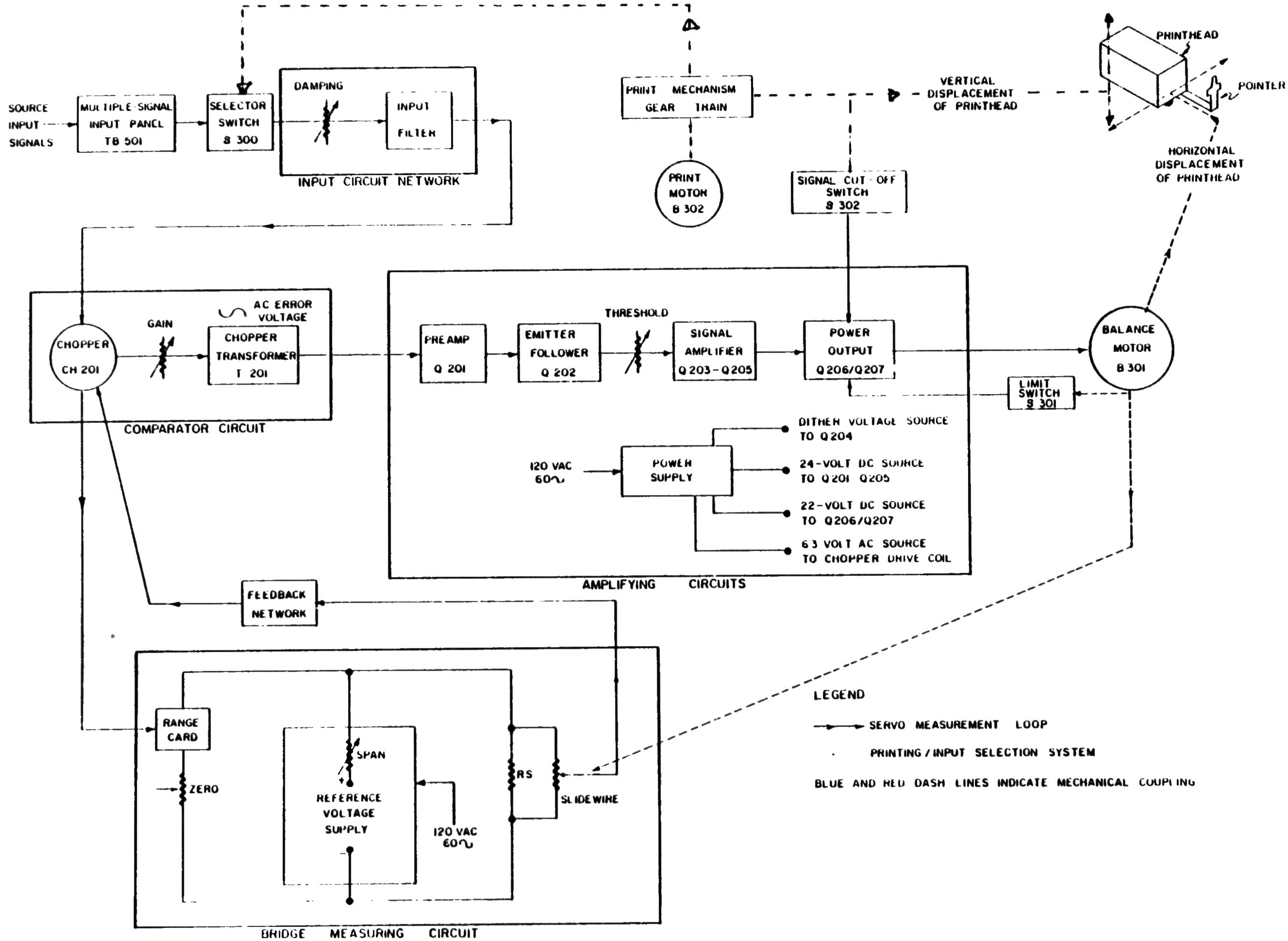


FIGURE 4 FUNCTIONAL BLOCK DIAGRAM OF MULTIPOINT RECORDER.

DATA MANIPULATION

All the time series data put into the Data Bank has to be in digital form, therefore, radiation monitor data of interest had to be digitized from the appropriate recordings. Enlarged color photographs were made of the stripcharts from all six recorders for approximately the first ten hours of the accident. The photographs were augmented by microfilms of the stripchart for digitizing up to 360 hours after the accident.

The first step in digitizing radiation monitor data was to identify the channel number on the recording corresponding to each particular health physics radiation monitor measurement channel. Using the color photographs it was possible to identify many of the blurred and partially printed numbers. In some cases the known color sequence of the numbers was used to aid in identification, although the color renditions were poor. In other instances it was necessary to search through the photographs to find an identifiable number then to literally follow the color print back and forth to identify its track. In still other cases the microfilm had to be used to find a clearly printed number which was then carefully followed forward and backward in time. Some channel numbers never were found and some channels were found which were not shown on the radiation monitor lists. There were cases where knowledge of the physical location of a monitor was used to identify it by comparison to a channel known to respond similarly. The most difficult part of digitizing the multipoint recordings was identifying the channel numbers.

The data were digitized either by estimating the radiation level value from photographs and recording by hand or by using a digitizing machine. On the digitizing apparatus the stripchart was mounted on an accurate x-y axis board. The x and y coordinate values were then fed directly into the computer by triggering the stylus on each data point.

The time base of each data set was undefined until the print frequency and paper speed were determined. All recorders used a paper speed of eight inches per hour or 7.5 minutes per division. This was established by correlating the time written by operators on the stripchart with the number of divisions the paper had advanced. It was found, however, that the print frequency between recorders varied, i.e., the number of times each measurement channel was printed per minute depended upon which recorder it was on. Time between data points was observed to vary between approximately 0.8 minutes and 1.4 minutes. For data digitized by machine no correction was necessary since the time between points could be defined at any desired value. The non-machine digitized data were adjusted so that the points were at the proper time intervals by using a multiplier on the time base points.

The individual pieces of the digitized data were combined into data sets of the desired length, one of which was 360 hours long. There were gaps in some data sets where the chart paper had slipped (generally due to torn paper). These gaps were left as blanks in the data. The time length of the gaps were determined knowing the time from the beginning of the accident sequence and the clock time written on the stripcharts. It was necessary to work both backward and foreward in time from the gaps to determine the proper time relationship.

The data set time bases, with properly timed gaps, were compared to the clock time written on the original stripcharts and a number of serious discrepancies were discovered where data had been digitized from the microfilm. It was found that some of these problems were due to errors in the digitizing process but other errors in the time base were unexplainable.

A careful study was then made of the stripchart channels and the time notations written on the stripcharts. Some places were found where there had been a paper slippage resulting in lost time manifested by closer than normal spacing of the channel print. The multiplicity of the time notations on the microfilm made it certain that the apparent time losses were real and not due to mistakes in operator notation. The rest of the time-loss periods, therefore, were attributed to a skip or loss of some section of the original data in the microfilm records. Whether the problem was in the original stripchart recording or in the filming process is unknown. Time base shifts were made where necessary to align the data with the clock time recorded on the stripcharts. Gaps were left in the data where this occurred.

Table 2 lists the data sets which have been digitized indicating the monitor detector or sampling location, the Data Base measurement identifier, and the corresponding stripchart recorder and channel. Figures for the 28 radiation monitor data sets are shown in Appendix A.

TABLE 2

LIST OF RADIATION MONITORS AND LOCATIONS

Monitoring Point	Stripchart Recorder	Channel Number	Measurement Identifier
Primary Coolant Letdown HI	HP-UR-3264	1	MU-R-720 H
Primary Coolant Letdown LO	HP-UR-3264	2	MU-R-720 L
Intermediate Coolant Letdown Cooler B	HP-UR-3264	3	IC-R-1091
Intermediate Coolant Letdown Cooler A	HP-UR-3264	4	IC-R-1092
Intermediate Coolant Letdown Cooler Outlet	HP-UR-3264	5	IC-R-1093
Plant Effluent Unit II	HP-UR-3264	6	WDL-R-1311
Decay Heat Closed A Loop	HP-UR-3264	7	DC-R-3399
Decay Heat Closed B Loop	HP-UR-3264	8	DC-R-3400
Spent Fuel Cooling	HP-UR-3264	10	SF-R-3402
RB Purge Unit Area	HP-UR-1902	7	HP-R-3236
Aux Bldg Exh Unit Area	HP-UR-1902	8	HP-R-3238
Fuel Handling Exh Unit Area	HP-UR-1902	9	HP-R-3240
RB Purge Air Exhaust Duct A	HP-UR-2900	1	HP-R-225-P
RB Purge Air Exhaust Duct A	HP-UR-2900	2	HP-R-225-I
RB Purge Air Exhaust Duct A	HP-UR-2900	3	HP-R-225-G
RB Purge Air Exhaust Duct B	HP-UR-2900	4	HP-R-226-P
RB Purge Air Exhaust Duct B	HP-UR-2900	5	HP-R-226-I
RB Purge Air Exhaust Duct B	HP-UR-2900	6	HP-R-226-G
Aux Bldg Purge Air Exhaust Upstream of Filter	HP-UR-2900	7	HP-R-222-P
Aux Bldg Purge Air Exhaust Upstream of Filter	HP-UR-2900	8	HP-R-222-I
Aux Bldg Purge Air Exhaust Upsteam of Filter	HP-UR-2900	9	HP-R-222-G
Aux Bldg Purge Air Exhaust Downstream of Filter	HP-UR-2900	10	HP-R-228-P
Aux Bldg Purge Air Exhaust Downstream of Filter	HP-UR-2900	11	HP-R-228-I
Aux Bldg Purge Air Exhaust Downstream of Filter	HP-UR-2900	12	HP-R-228-G
Waste Gas Discharge Duct	HP-UR-3236	4	WGD-R-1480-G
Station Vent	HP-UR-1907	3	HP-R-219-G
Hydrogen Purge	HP-UR-1907	15	HP-R-229-G
Intermediate Cooling Pump Area	HP-UR-1901	6	HP-R-207

DATA UNCERTAINTY AND QUALIFICATION

The quality of the radiation monitor data recorded during the TMI-2 accident and subsequently put on the Data Base was established. This was necessary so that users of these data would know the inherent errors in the data and, therefore, be able to calculate the total error band in any analyses performed with these data.

A formal system exists for determining the uncertainty in the measurement data.[3-5] Basically, this system consists of: (1) compiling the useful data in a usable form, (2) gathering all available technical information on transducers, signal conditioning, and recording instruments, (3) gathering all available calibration data, (4) performing an uncertainty analysis on each measurement channel.

Data is classified as Qualified, Trend, or Failed. The "Qualified Data" is data which have established uncertainties, have been corrected for all known errors, and are considered a reasonably repeatable representation of the physical phenomenon being measured, i.e., the gamma or beta radiation level at the detector location. The "Trend Data" are considered to be only an approximation of the phenomenon being measured, may not be repeatable, and have unacceptably large uncertainties. "Failed Data" contain no useful information.

The radiation levels measured by all the radiation monitors are classified as "Trend Data". This classification was assigned because of the unacceptably large uncertainty found in these measurement values. From a study of the recorded radiation levels it was concluded that (1) there were large uncertainties in the measurements after calibration, (2) there was no evidence that the detectors had been calibrated within years of the accident, (3) radiation effects on the electronic systems may have influenced readings after the accident.

The time-base of the data were classified as qualified and uncertainties were assigned to each data set as indicated in Table 3. The uncertainties in the time-bases were estimated from the work done in establishing and correcting the time-base of each data set. No formal uncertainty analysis could be made on the radiation monitor data, either radiation levels or the time-base.

TABLE 3

TIME BASE MEASUREMENT QUALITY CATEGORIES

Measurement Identifier	Quality Classification	Uncertainty* (± Minutes)
HP-R-207	Qualified	10
HP-R-3236	Qualified	15
HP-R-3238	Qualified	15
HP-R-3240	Qualified	15
HP-R-219	Qualified	2
HP-R-229	Qualified	2
HP-R-225	Qualified	2
HP-R-226	Qualified	2
HP-R-222	Qualified	2
HP-R-228	Qualified	2
WGD-R-1480	Qualified	2
MU-R-720	Qualified	5
IC-R-1091	Qualified	5
IC-R-1092	Qualified	5
IC-R-1093	Qualified	5
WDL-R-1311	Qualified	5
DC-R-3399	Qualified	5
DC-R-3400	Qualified	5
SF-R-3402	Qualified	5

*Uncertainties are estimated to be at the 95% confidence level.

SUMMARY

The health physics radiation monitors and data from the TMI-2 reactor facility are the subjects of this report. These data were recorded on multipoint stripcharts from which microfilm and color photographs were made. The data were digitized from both the photographs and films for times up to 360 hours.

The amplitude of the radiation monitor outputs was determined to be "Trend Data" because of the large uncertainties in the values and the possibility of the high radiation fields affecting detector operation. The time-base, on the other hand, was considered to be "Qualified Data" after it was extensively corrected. Confidence in the accuracy of the time-base was enhanced by the multitude of clock times written on the original stripcharts by the operators. No formal uncertainty analysis could be made on these data but it is estimated that the time-base uncertainties are at the 95% confidence level.

There were a total of 28 data channels digitized from the available radiation monitor data. These data were selected mostly because they were considered to be of immediate interest of analysts.

REFERENCES

1. Analysis of Three Mile Island Unit 2 Accident, NSAC-80-1, March 1980.

2. Interpretation of TMI-2 Instrument Data, NSAC-28, May 1982.

3. R. B. Abernethy, R. P. Benedict, "Measurement Uncertainty: A Standard Methodology," ISA Transactions, Vol. 24, Number 1, 1985.

4. R. B. Abernethy, et. al., "Measurement Uncertainty Handbook," AEDC-TR-73-5, Revised 1980.

5. Measurement Uncertainty for Fluid Flow in Closed Circuits, ANSI/ASME MFC-2M-1983.

APPENDIX A

DATA PLOTS

This appendix contains the plots of all the health physics radiation monitor data which are discussed in this report and put into the TMI-2 Data Base.

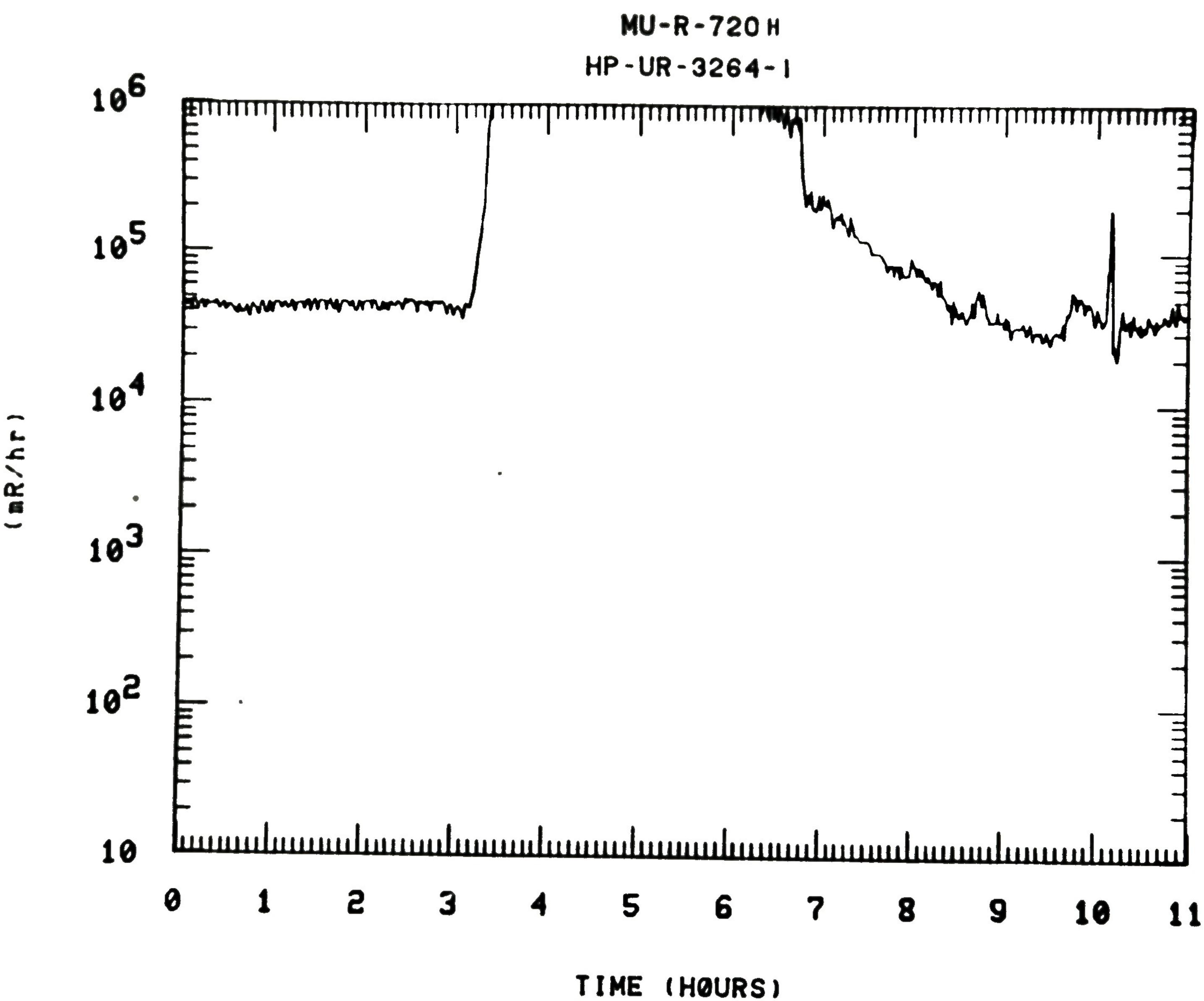


Figure A-1. Primary coolant letdown HI.

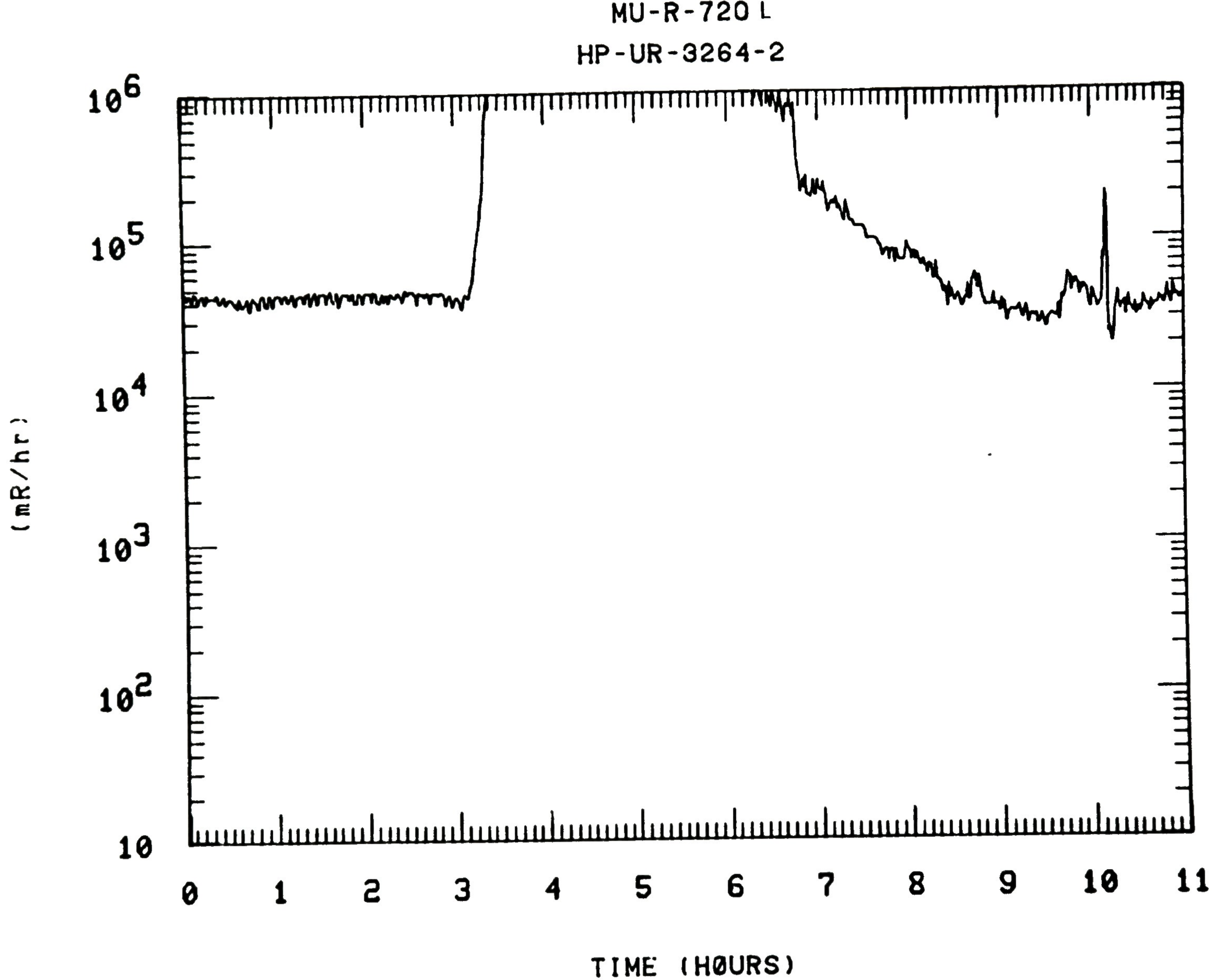


Figure A-2. Primary coolant letdown LO.

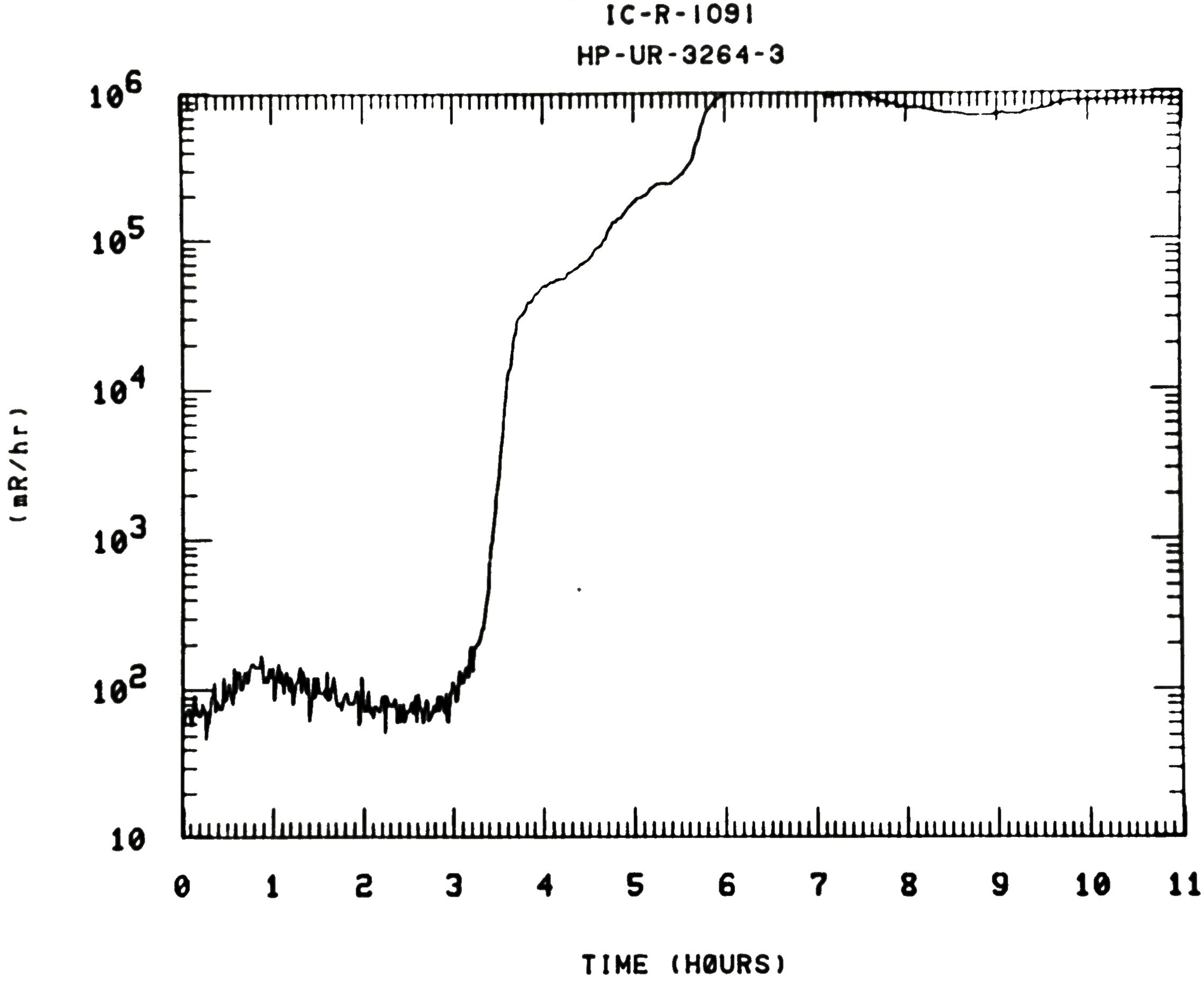


Figure A-3. Intermediate coolant letdown cooler B.

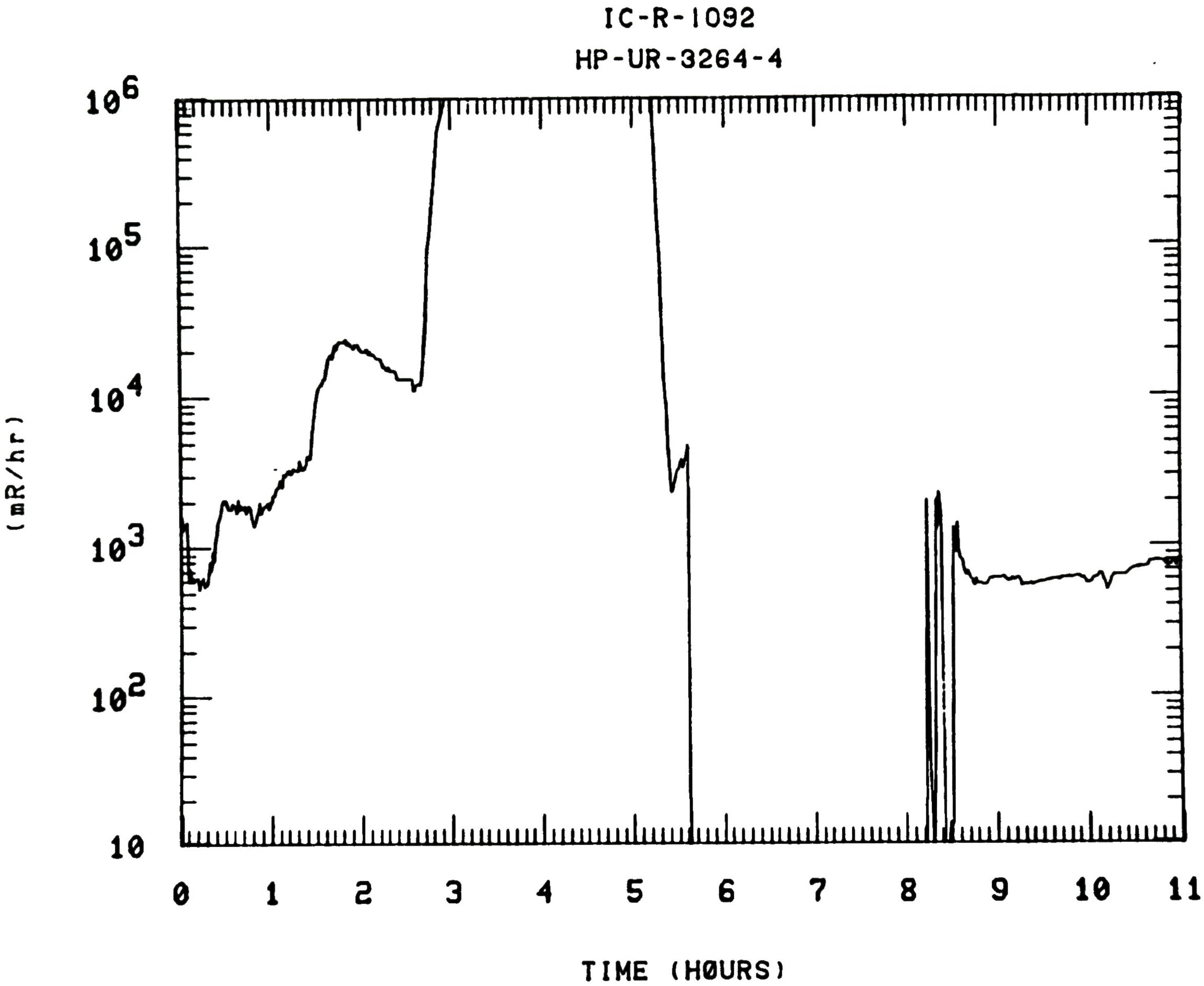


Figure A-4. Intermediate coolant letdown cooler A.

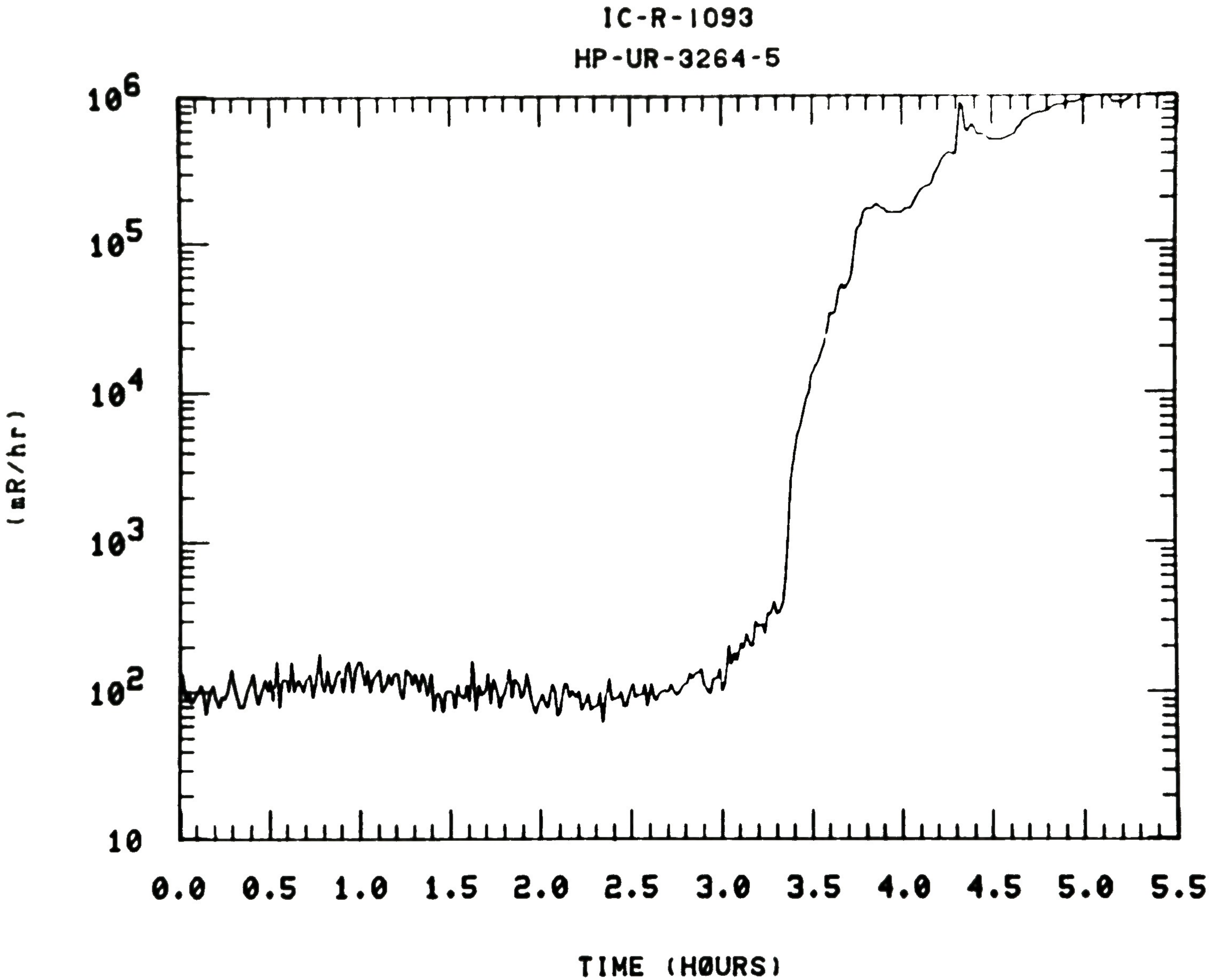


Figure A-5. Intermediate coolant letdown cooler outlet.

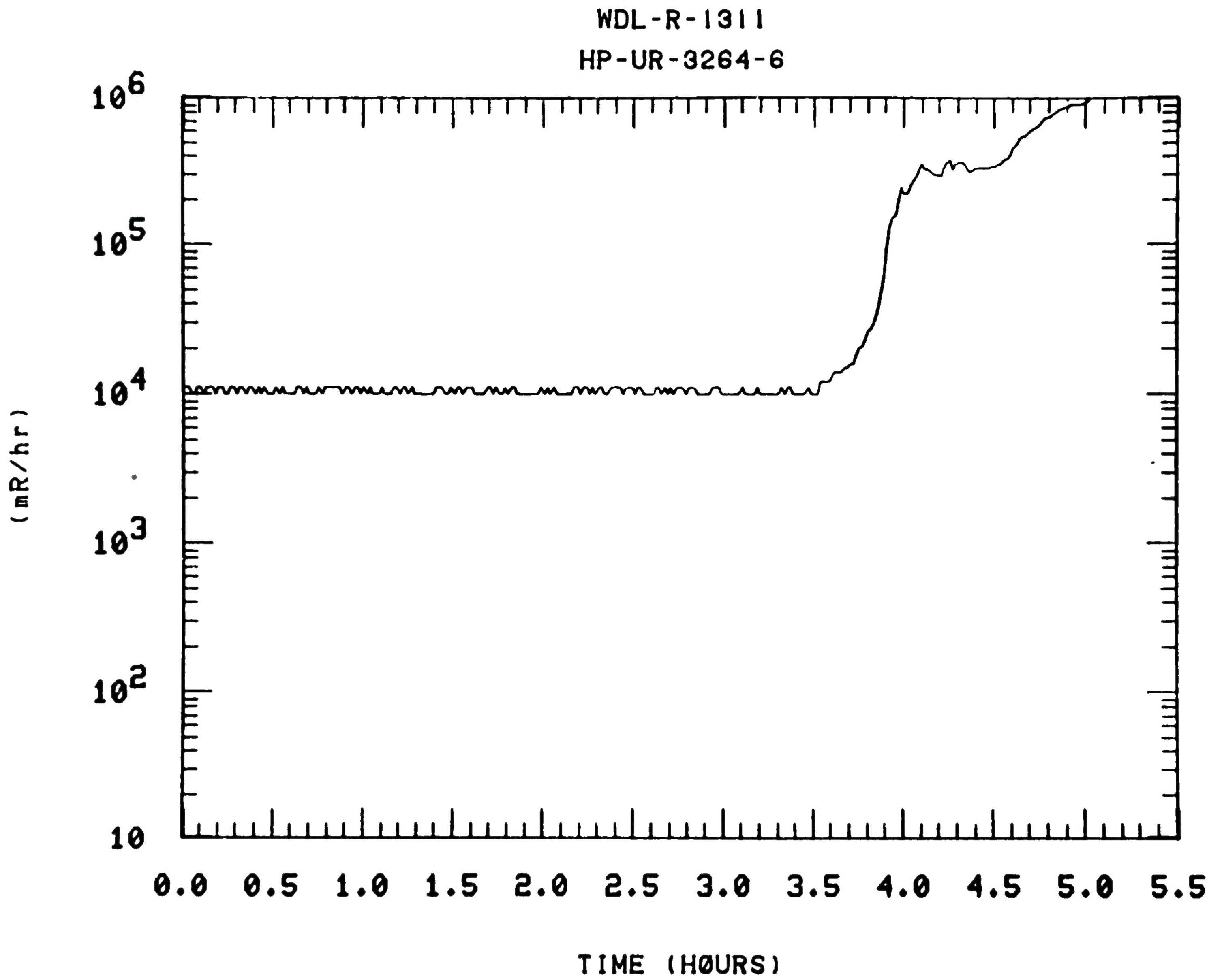


Figure A-6. Plant effluent unit II.

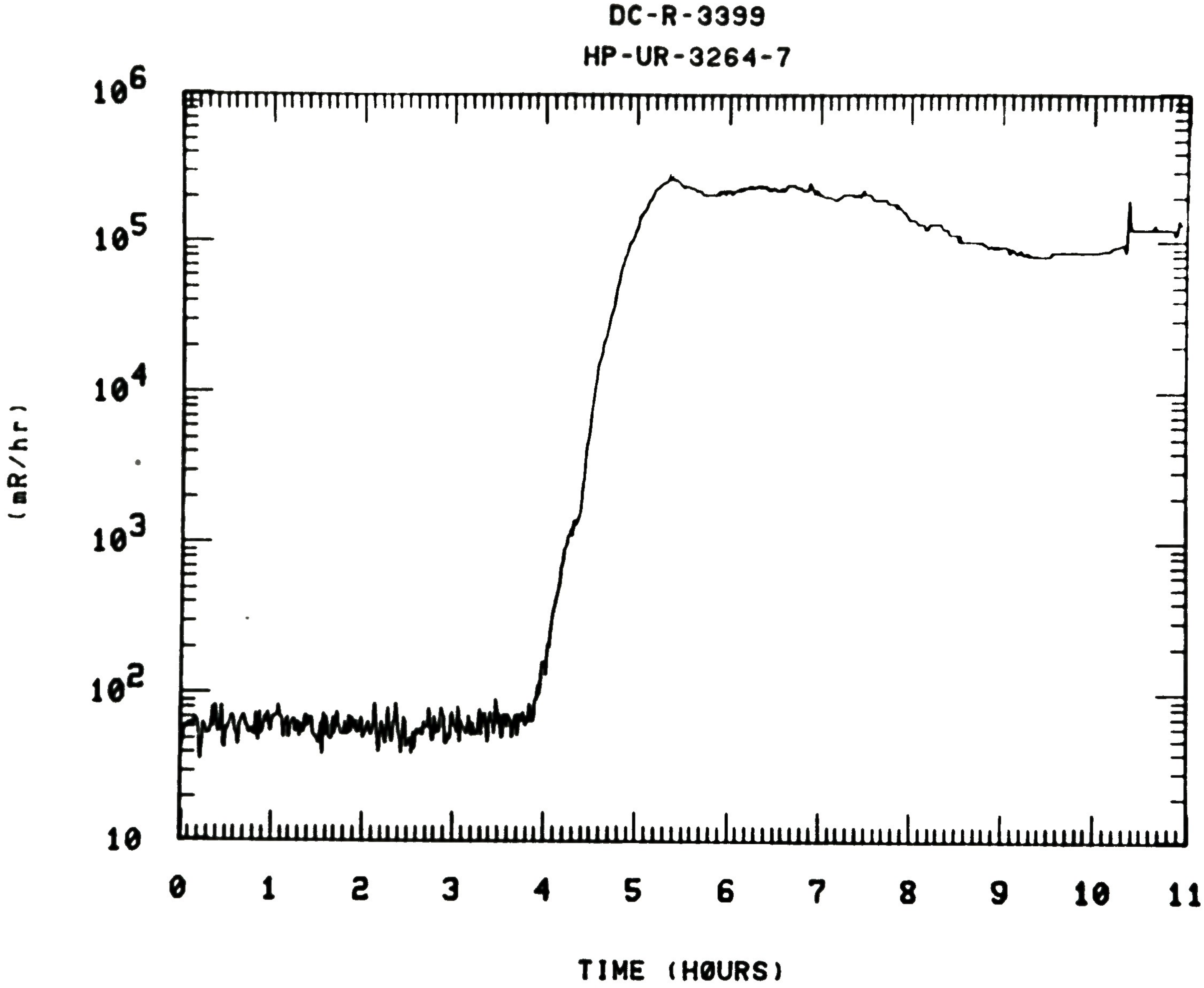


Figure A-7. Decay heat closed a loop.

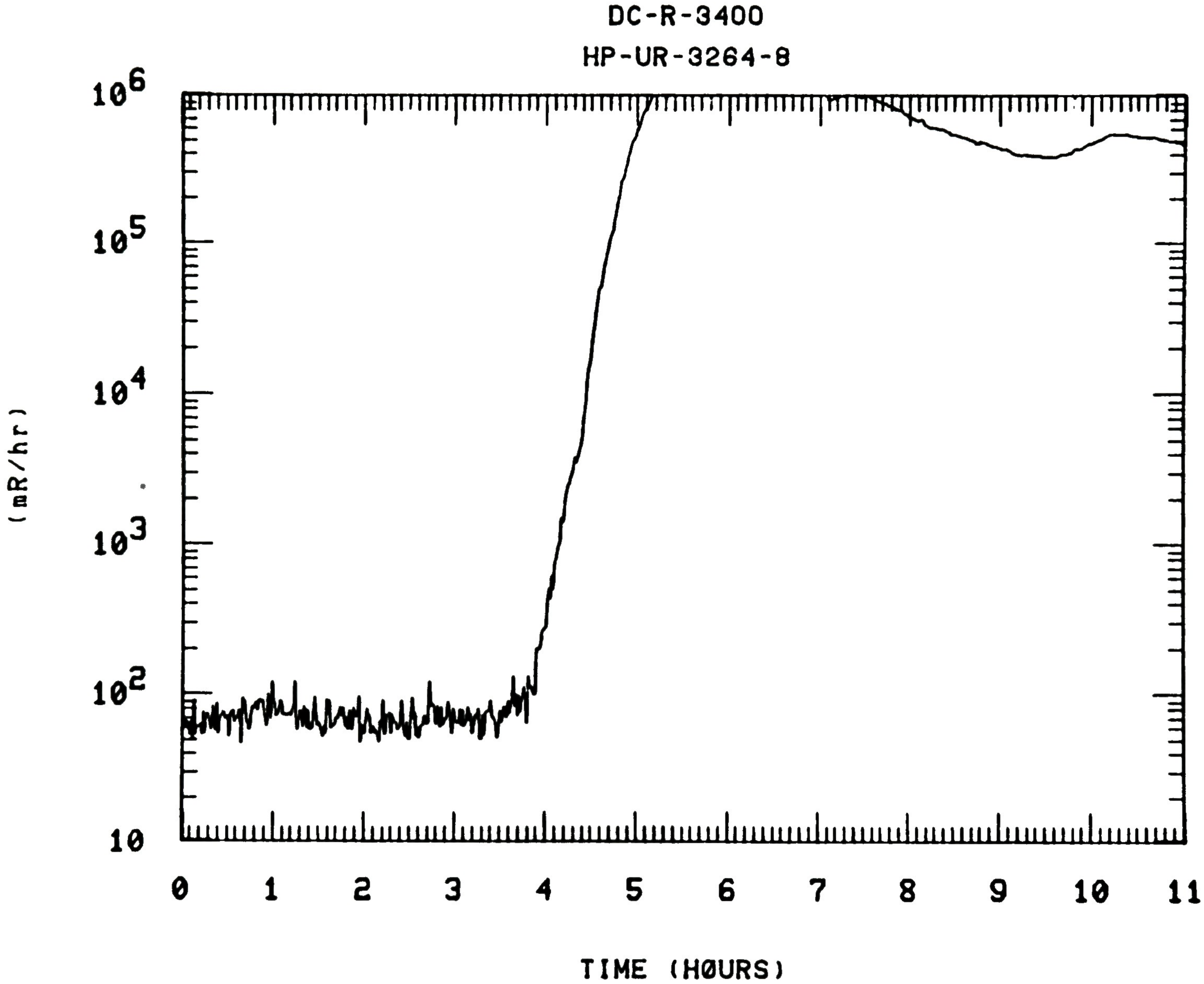


Figure A-8. Decay heat closed B loop.

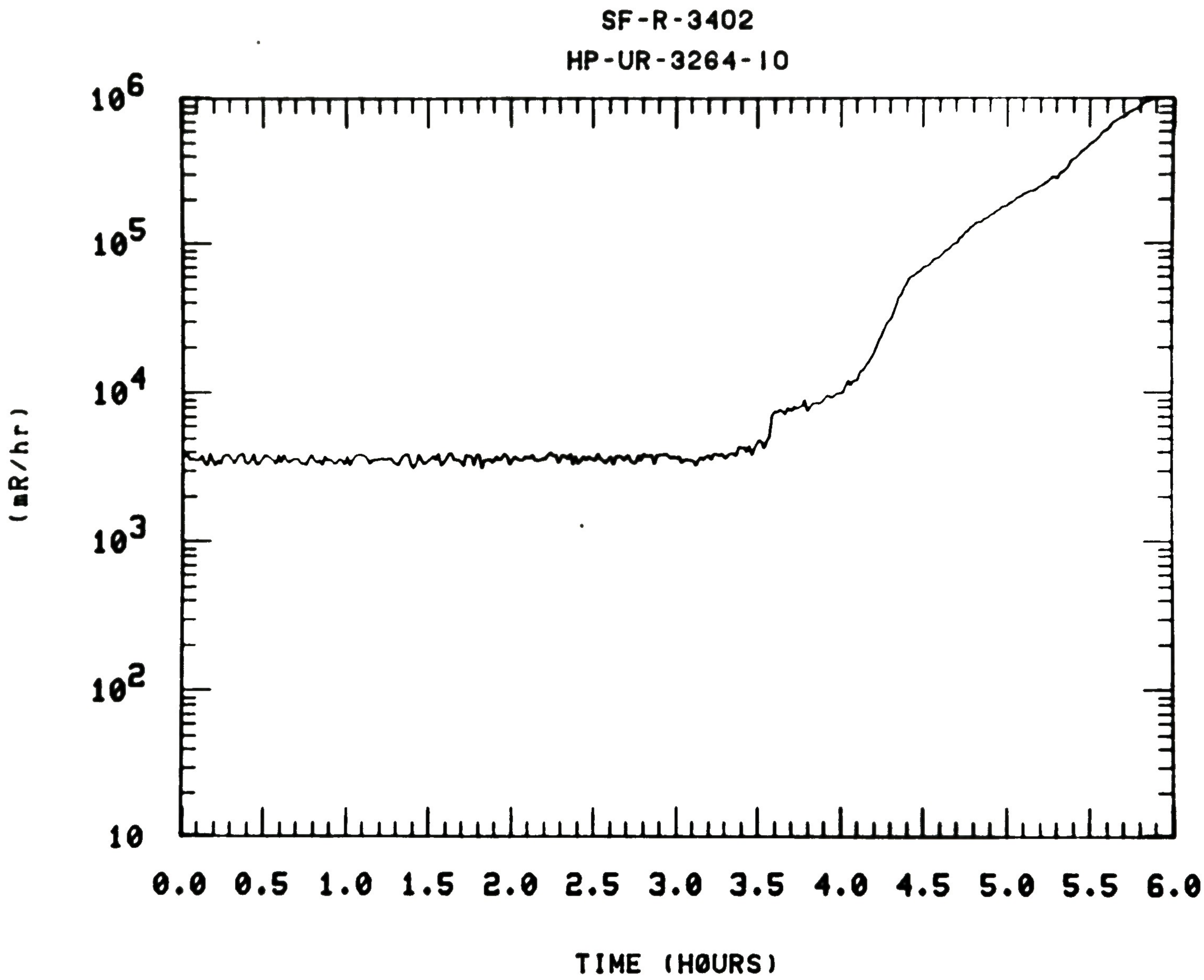


Figure A-9. Spent fuel cooling.

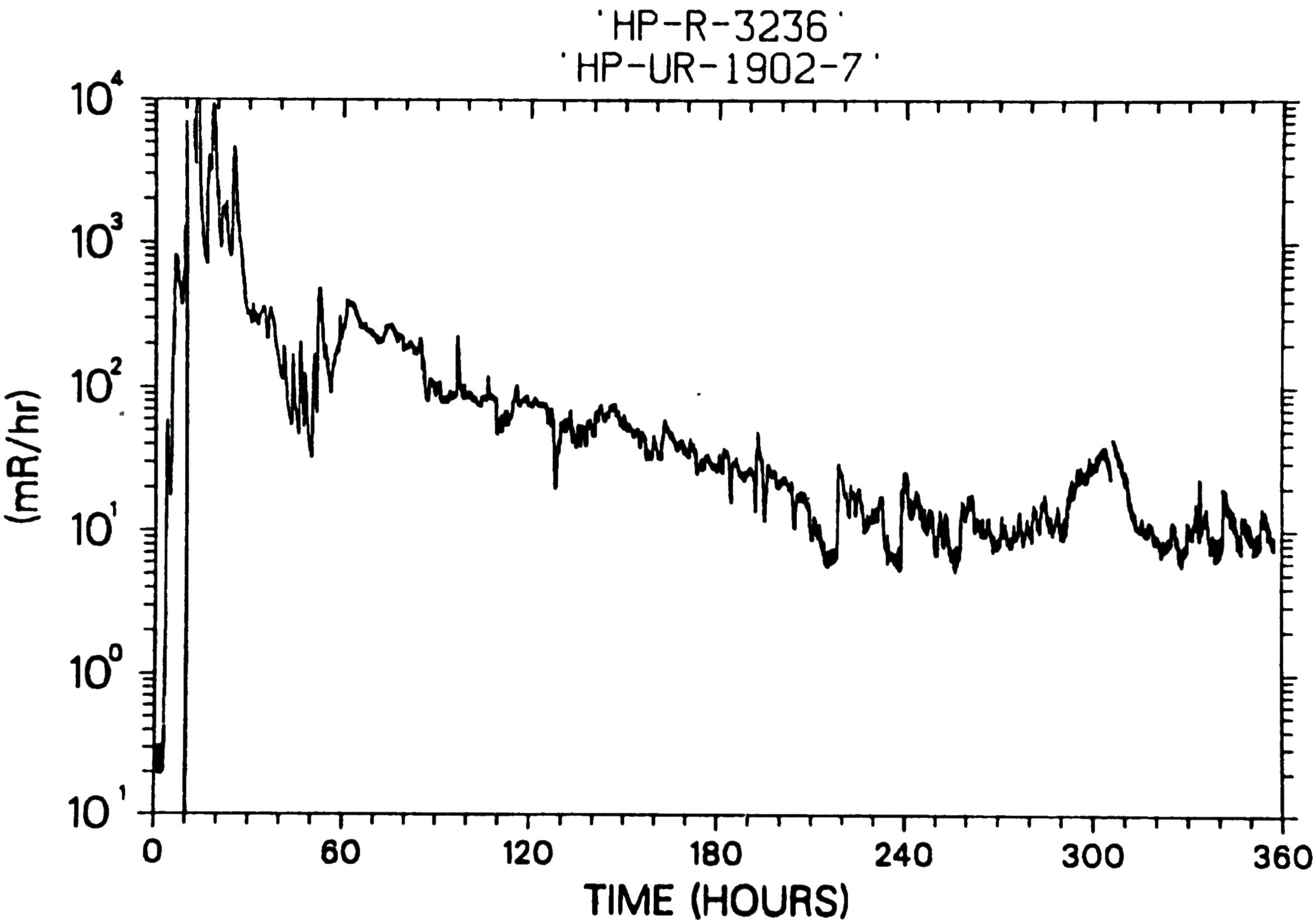


Figure A-10. RB purge unit area.

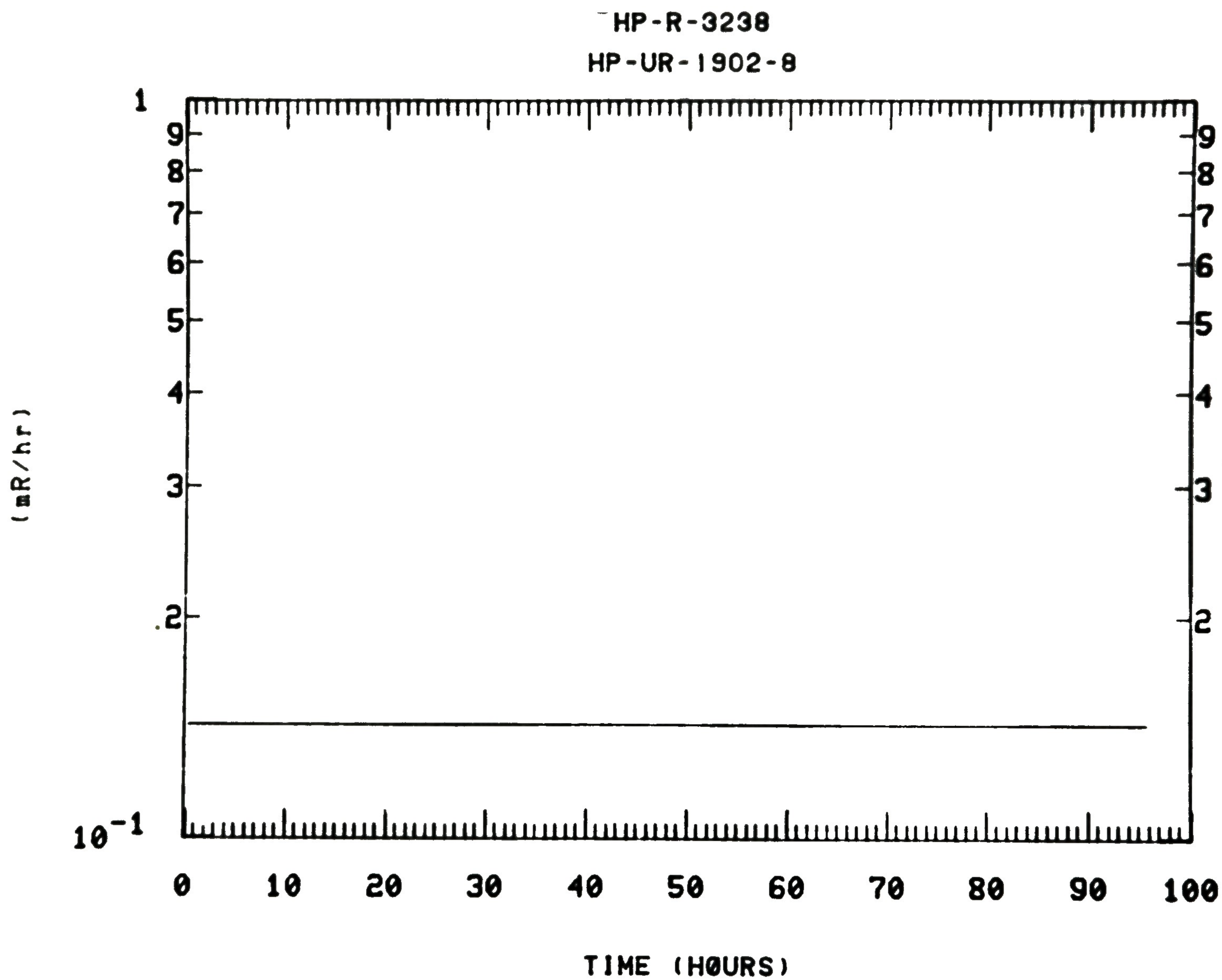


Figure A-11. Auxiliary building exhaust unit area.

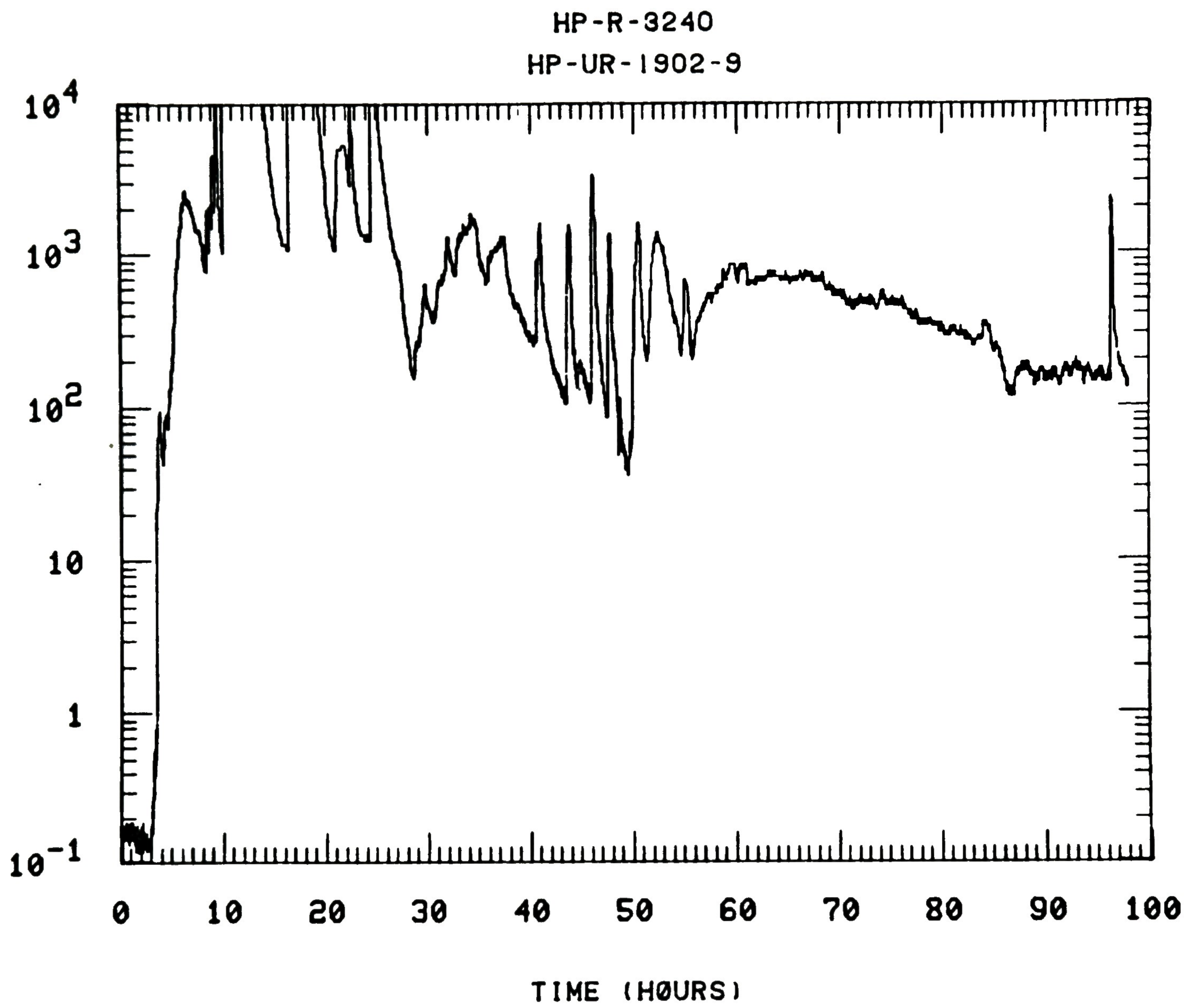


Figure A-12. Fuel handling exhaust unit area.

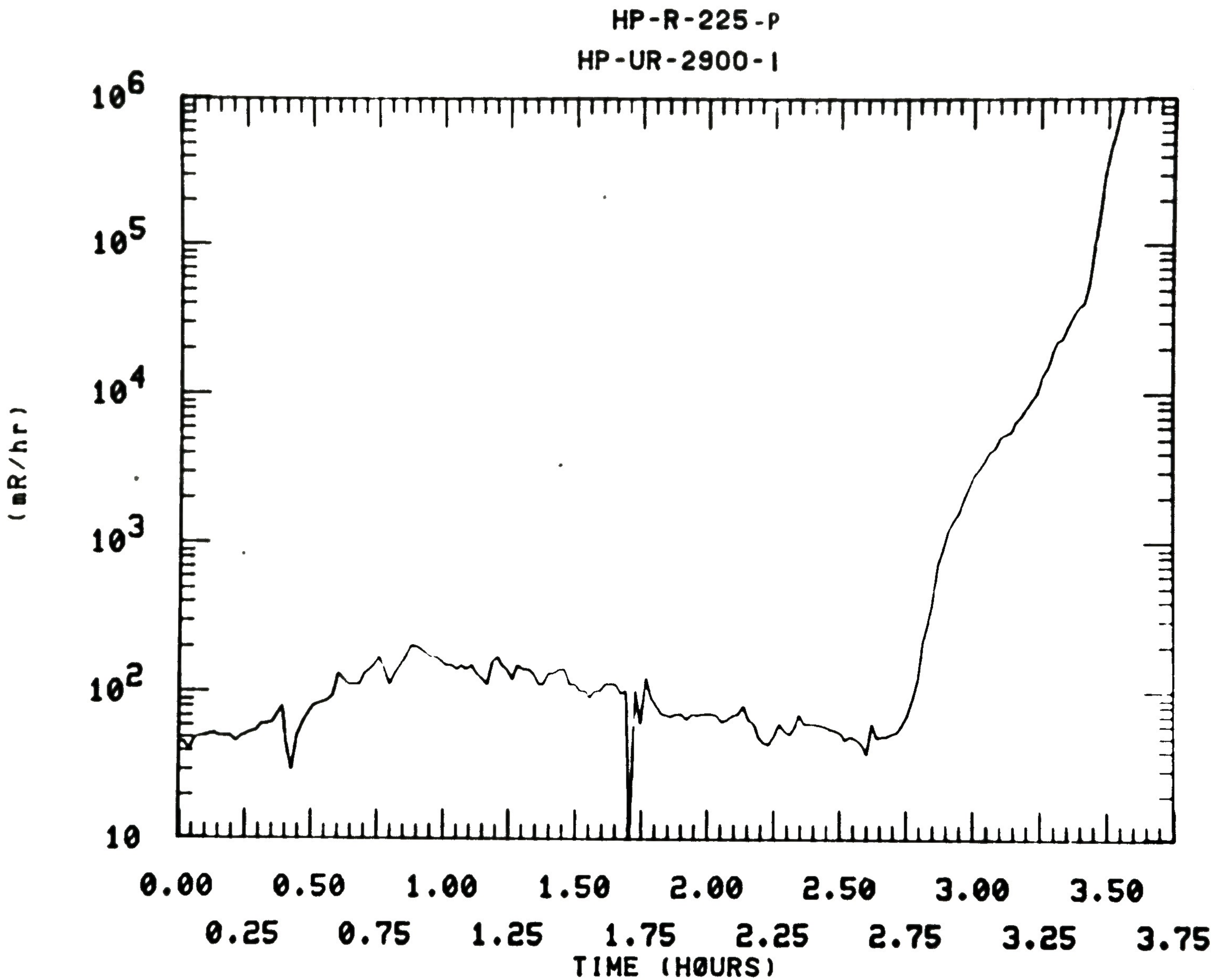


Figure A-13. RB purge air exhaust duct A.

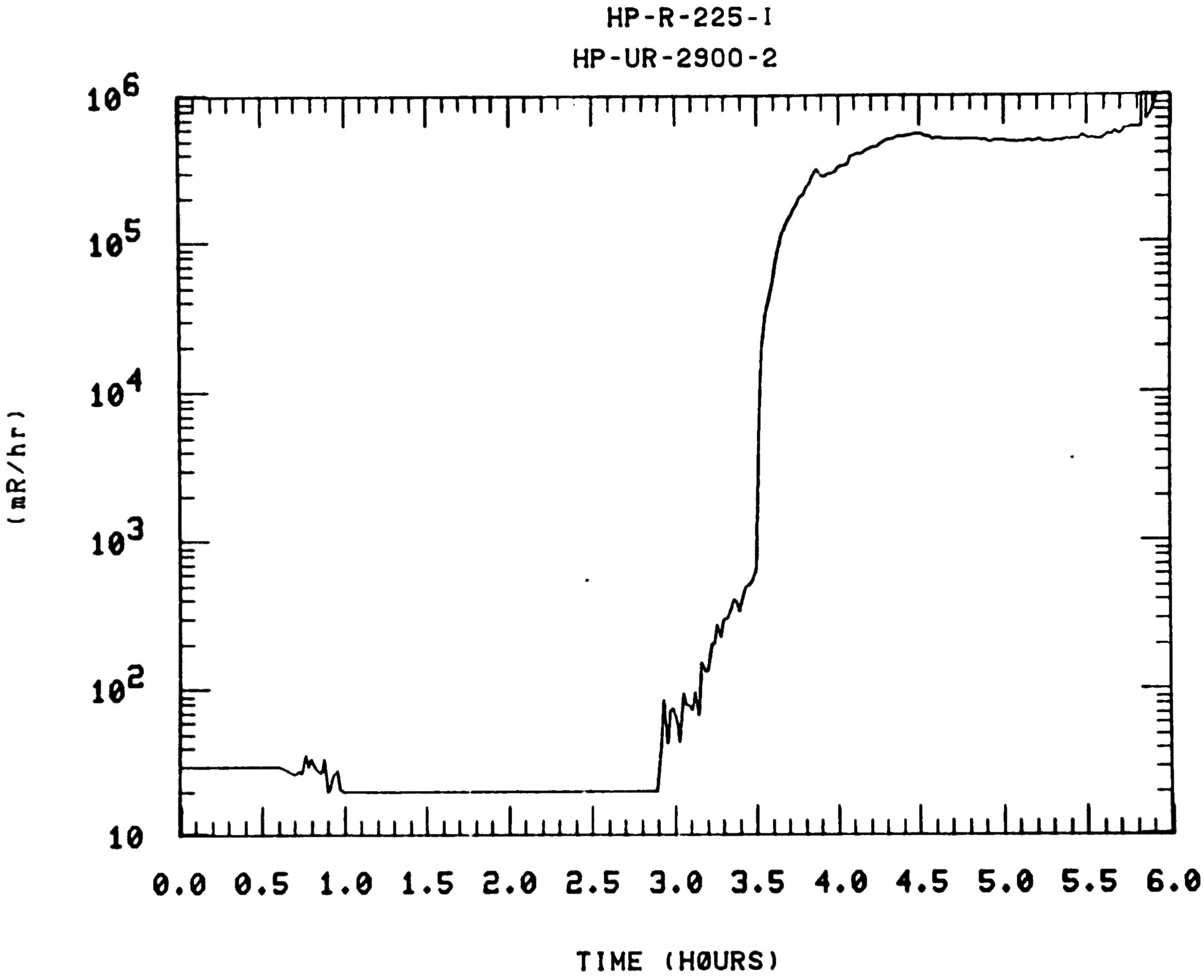


Figure A-14. RB purge air exhaust duct A.

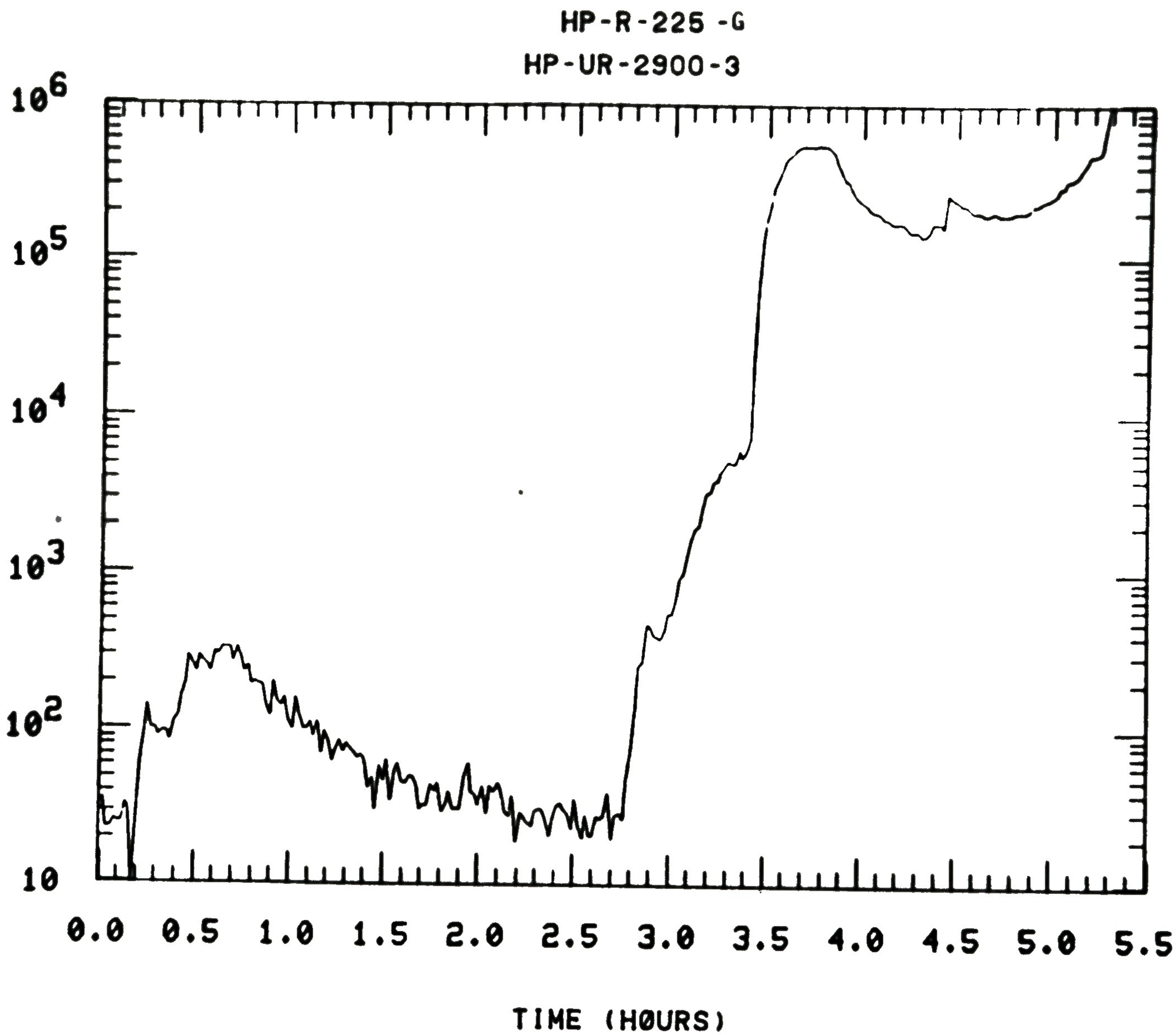


Figure A-15. RB purge air exhaust duct A.

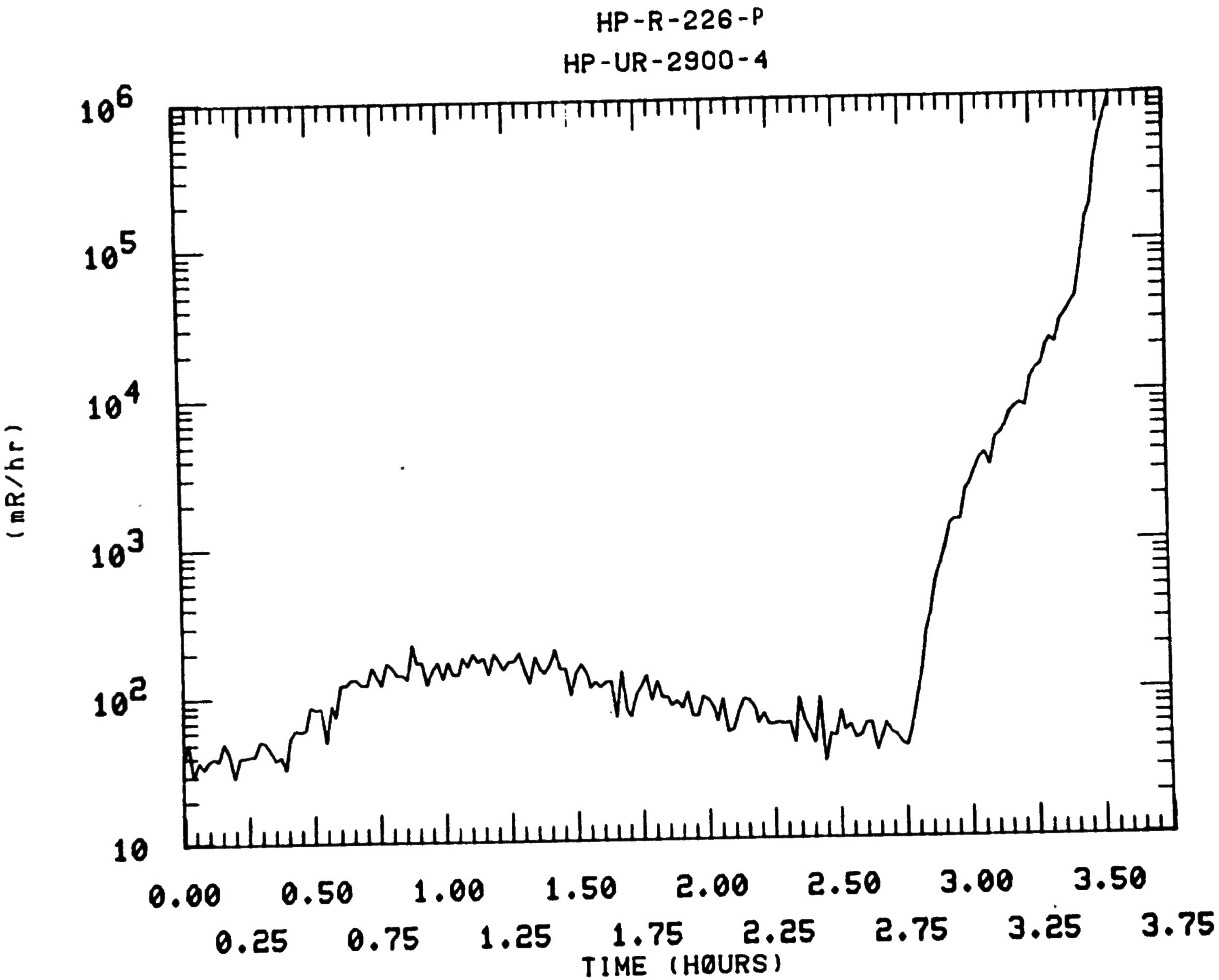


Figure A-16. RB purge air exhaust duct B.

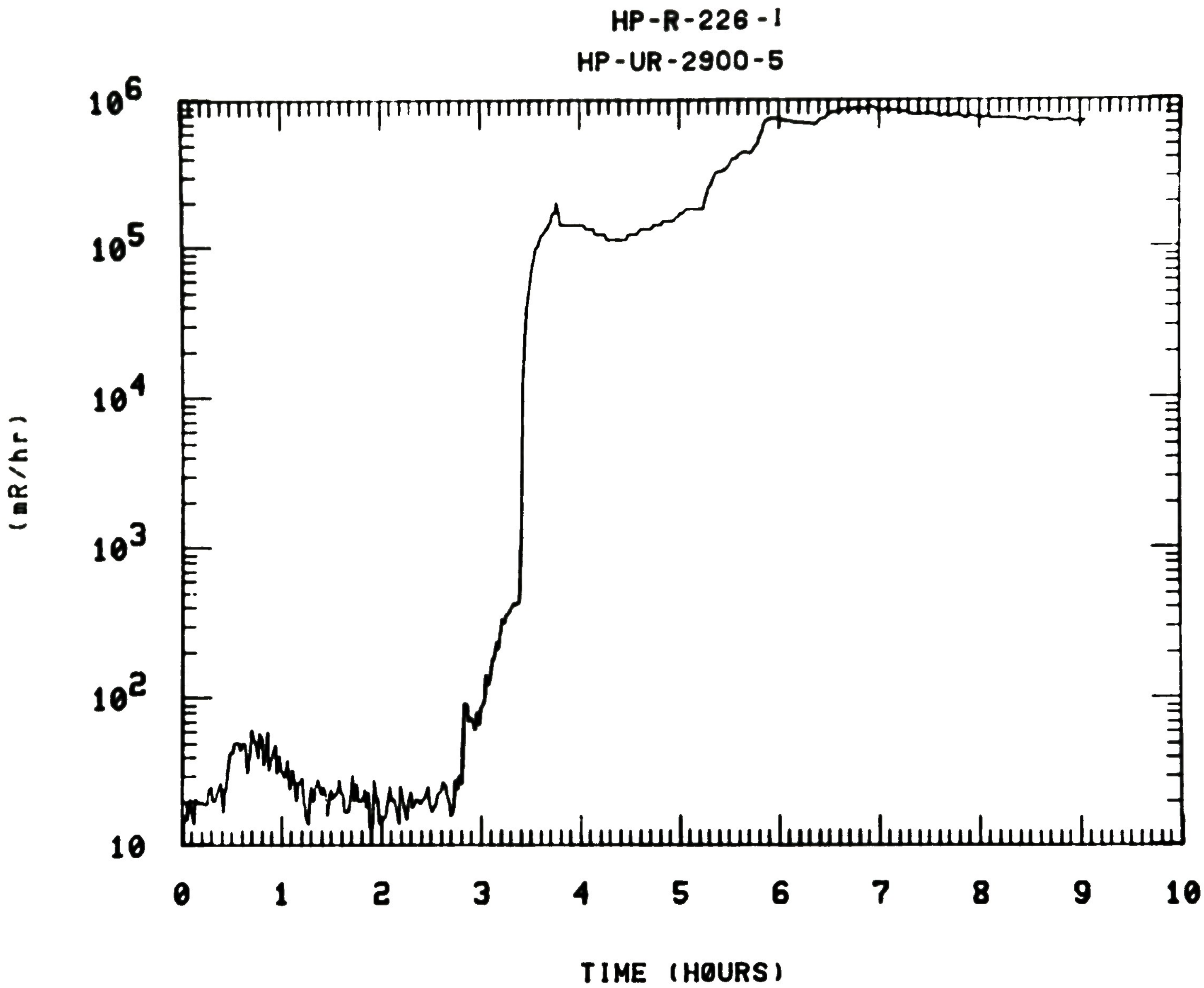


Figure A-17. RB purge air exhaust duct B.

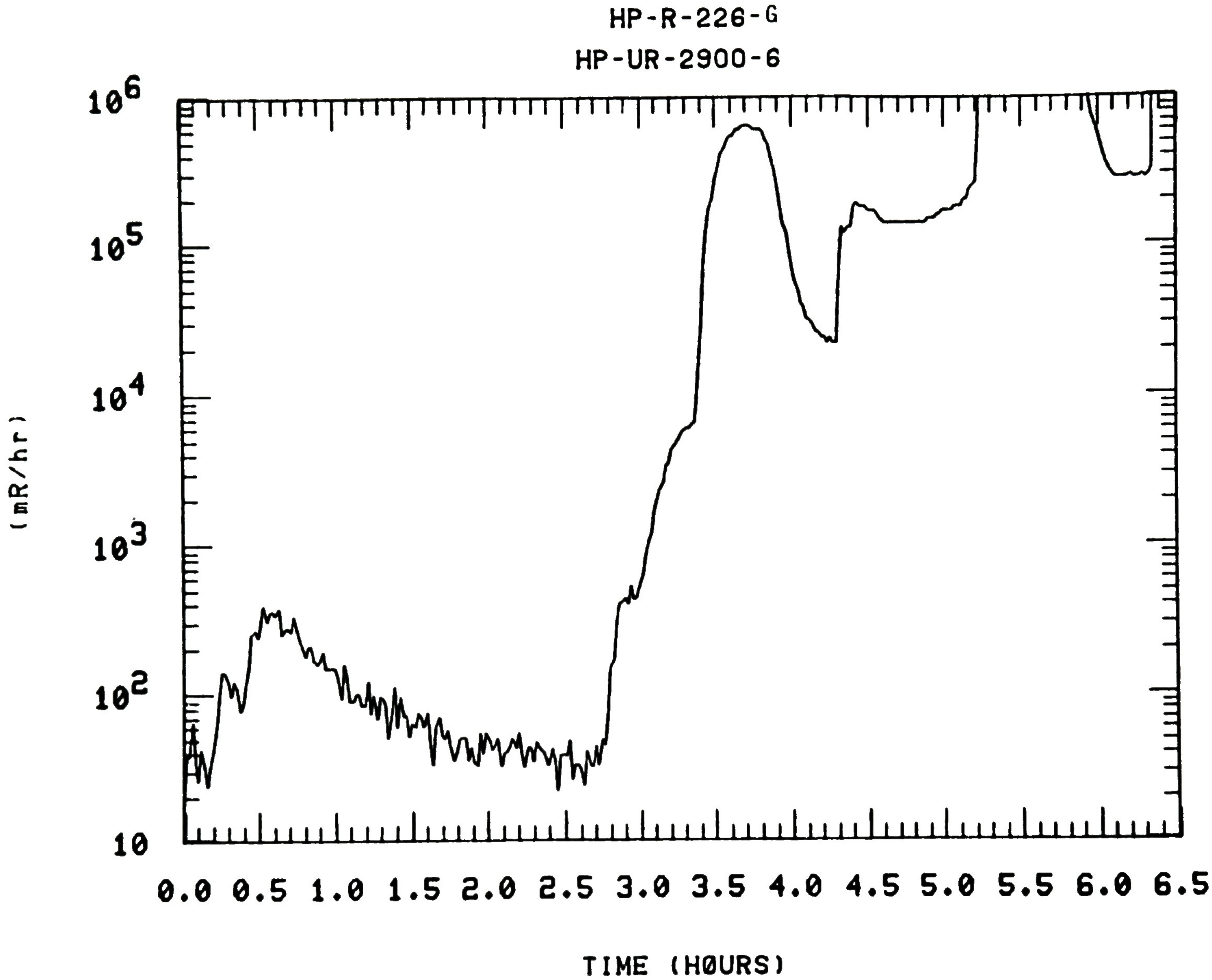


Figure A-18. RB purge air exhaust duct B.

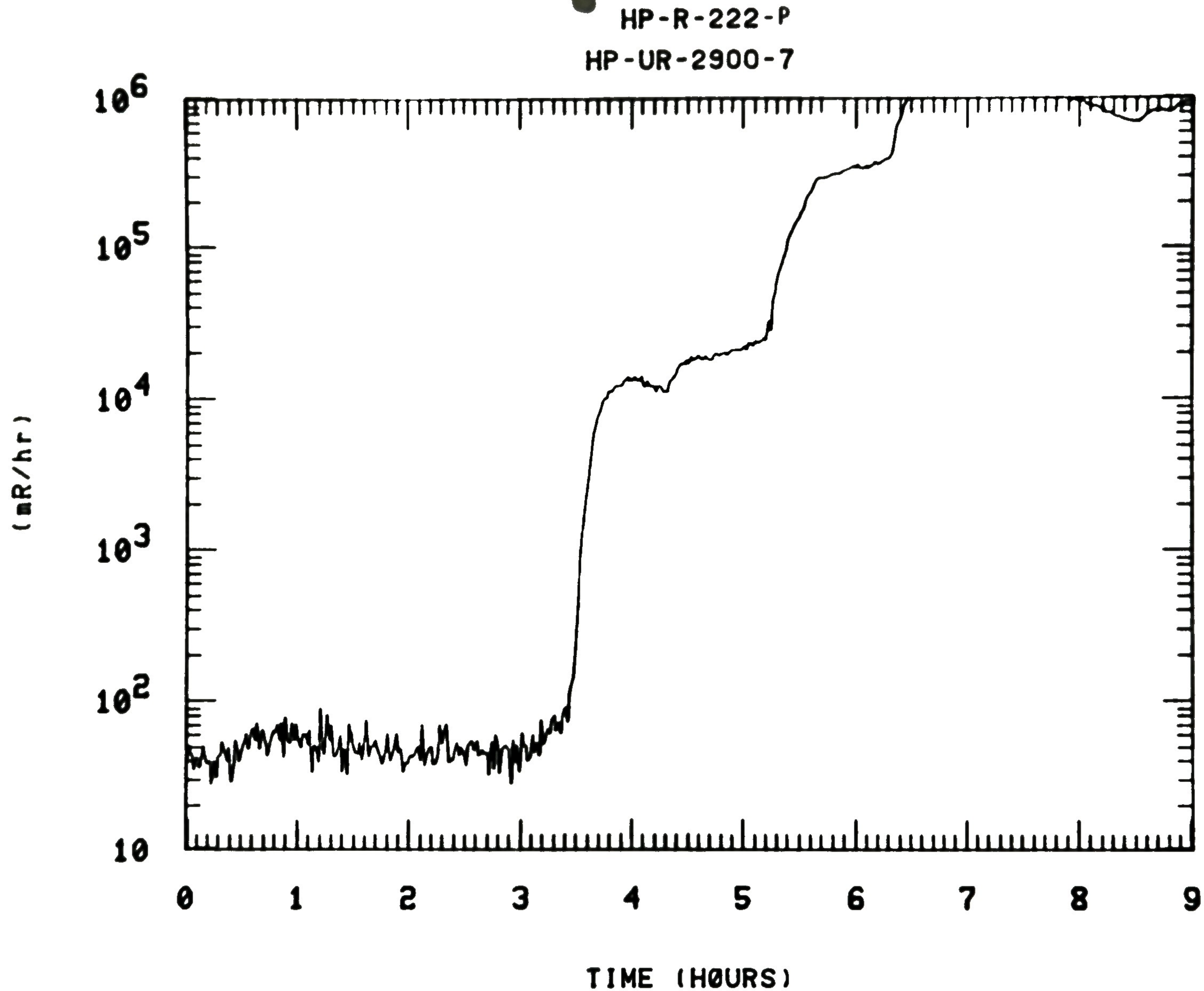


Figure A-19. Auxiliary building purge air exhaust upstream of filter.

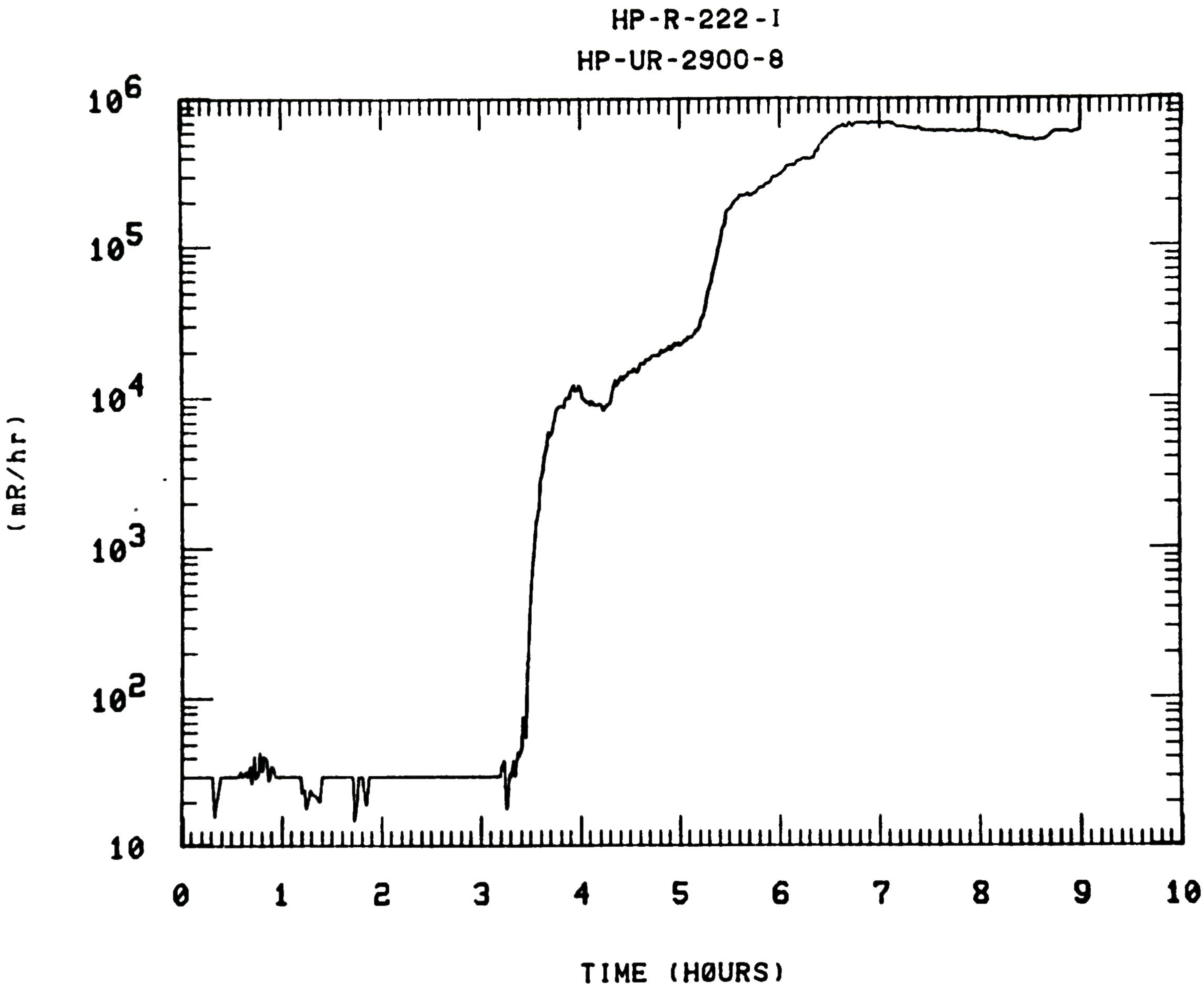


Figure A-20. Auxiliary building purge air exhaust upstream of filter.

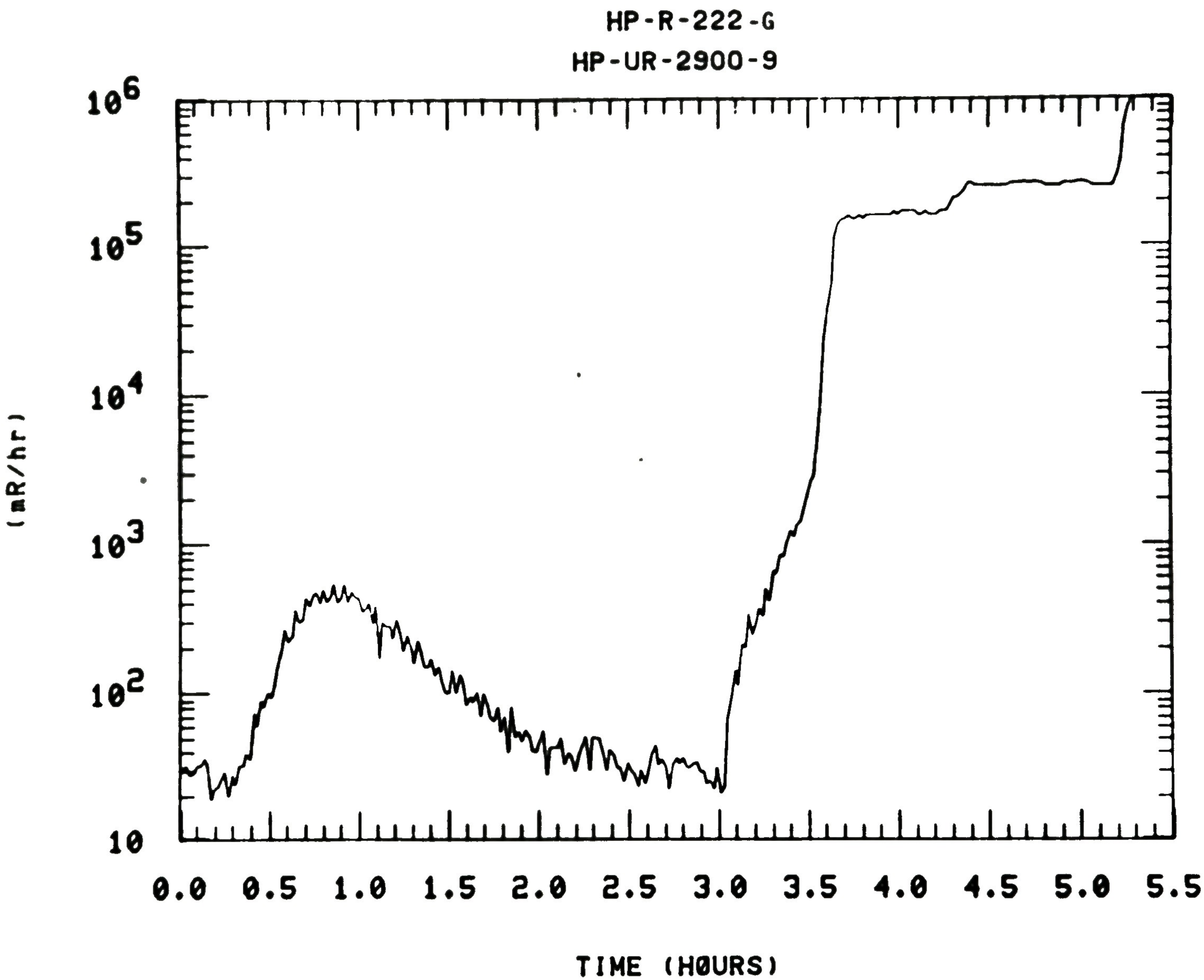


Figure A-21. Auxiliary building purge air exhaust upstream of filter.

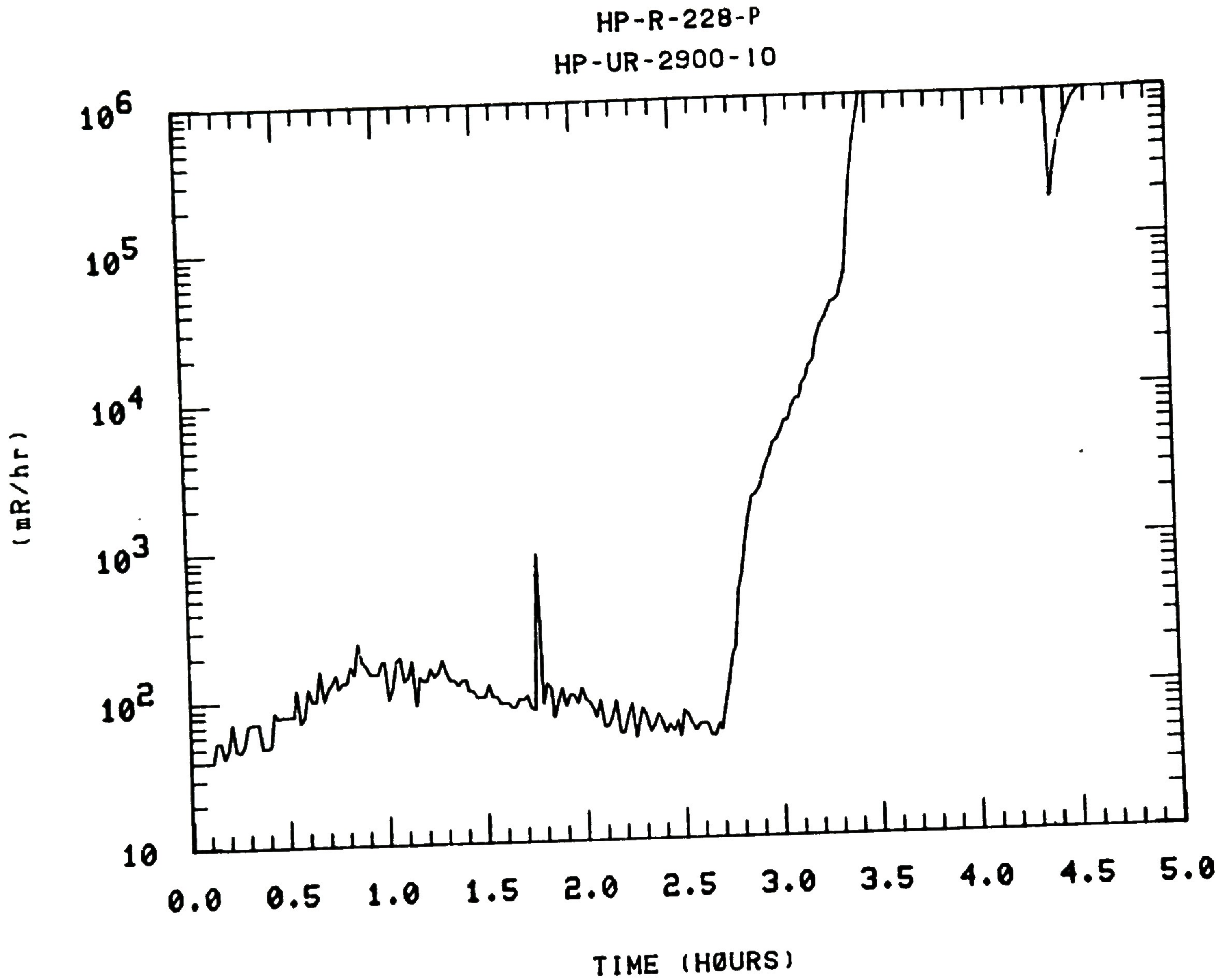


Figure A-22. Auxiliary building purge air exhaust downstream of filter.

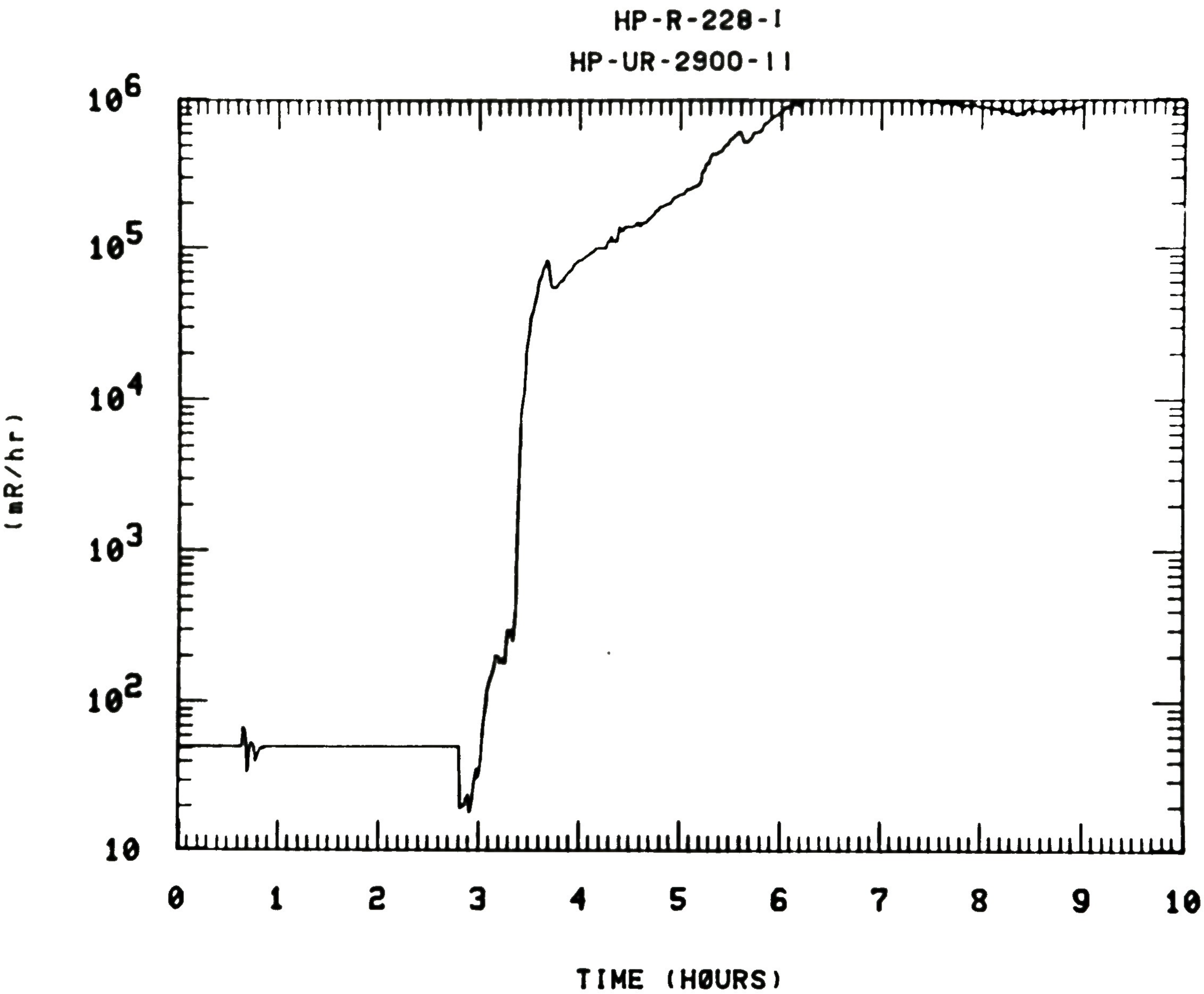


Figure A-23. Auxiliary building purge air exhaust downstream of filter.

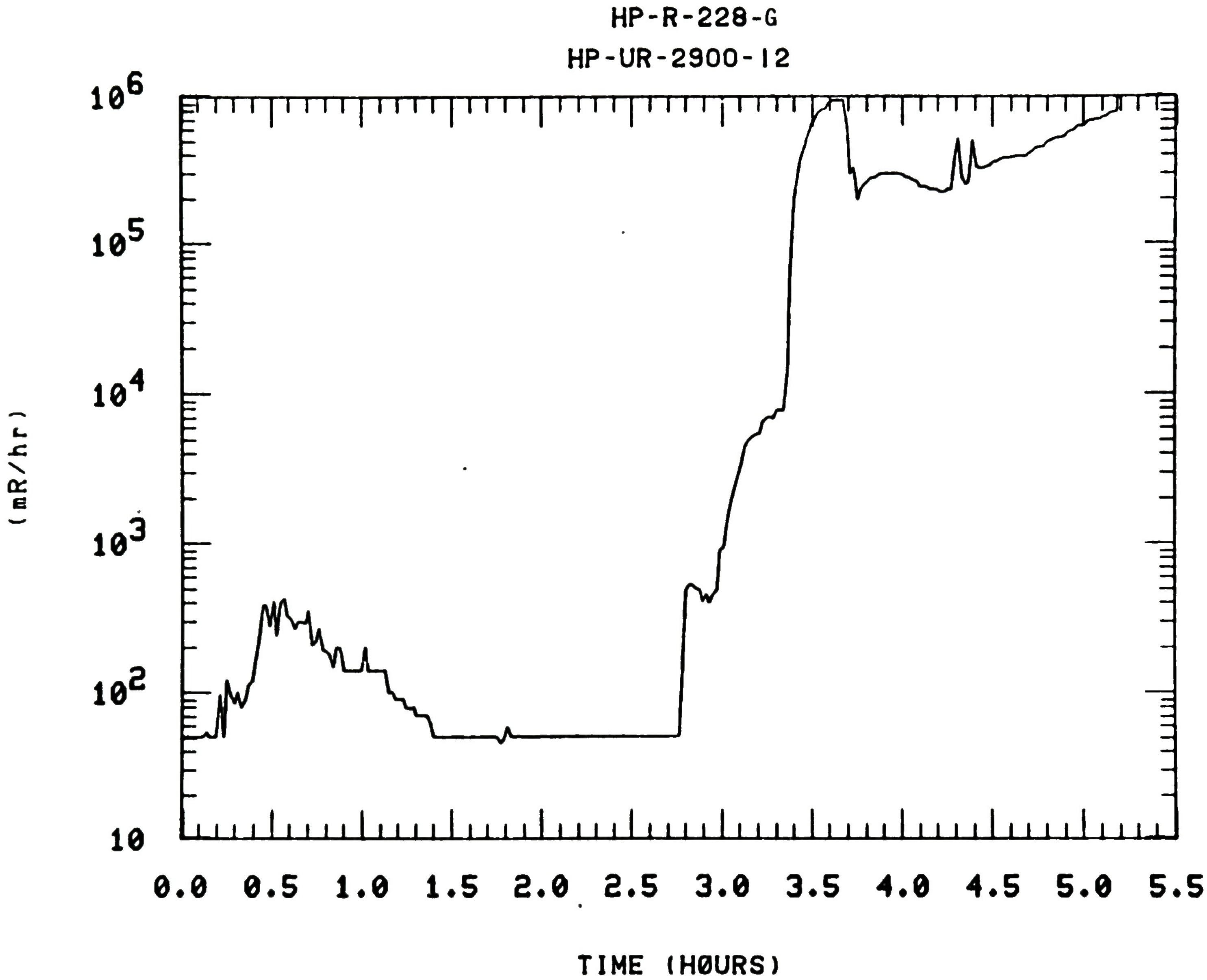


Figure A-24. Auxiliary building purge air exhaust downsteam of filter.

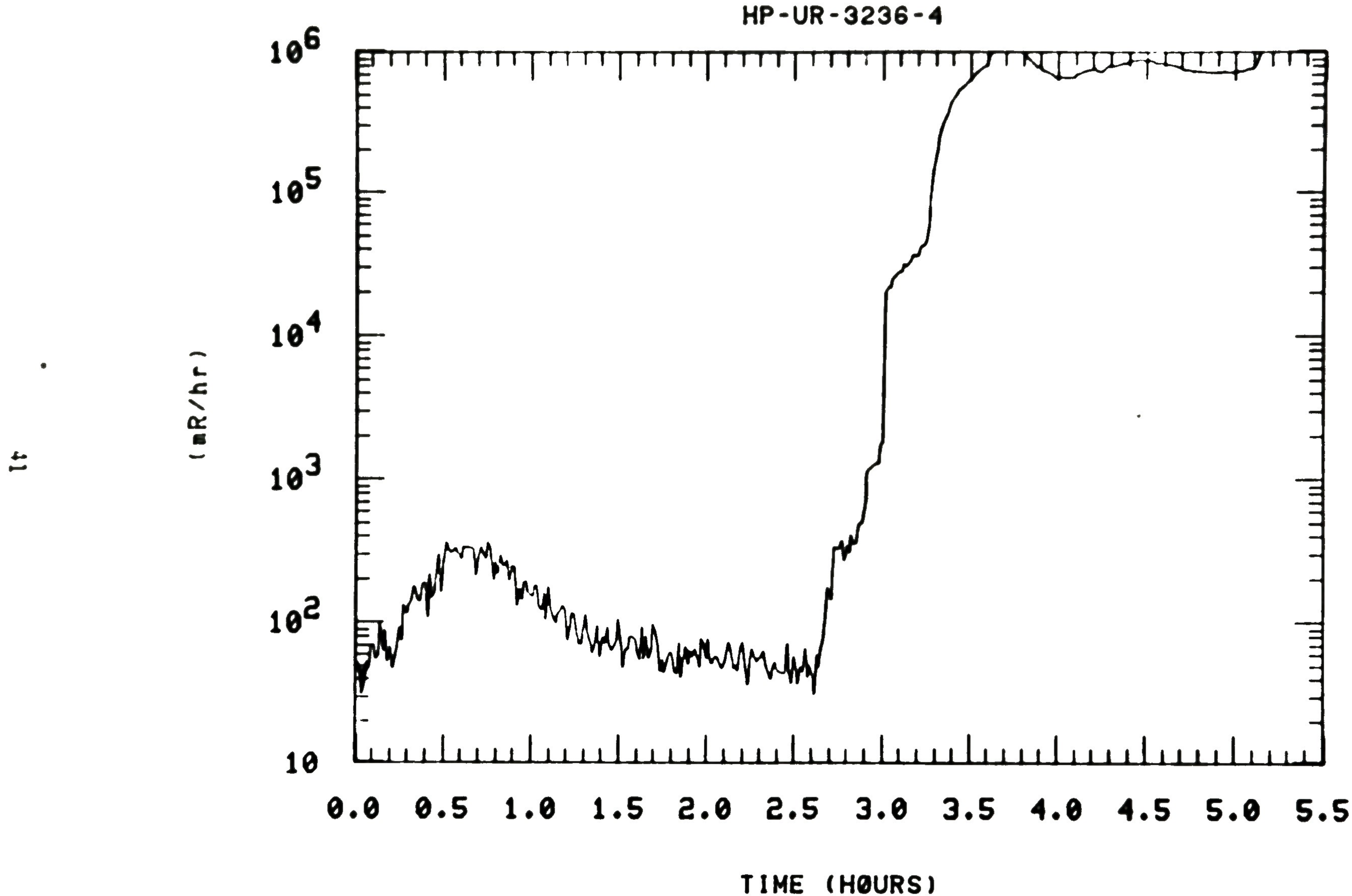


Figure A-25. Waste gas discharge duct.

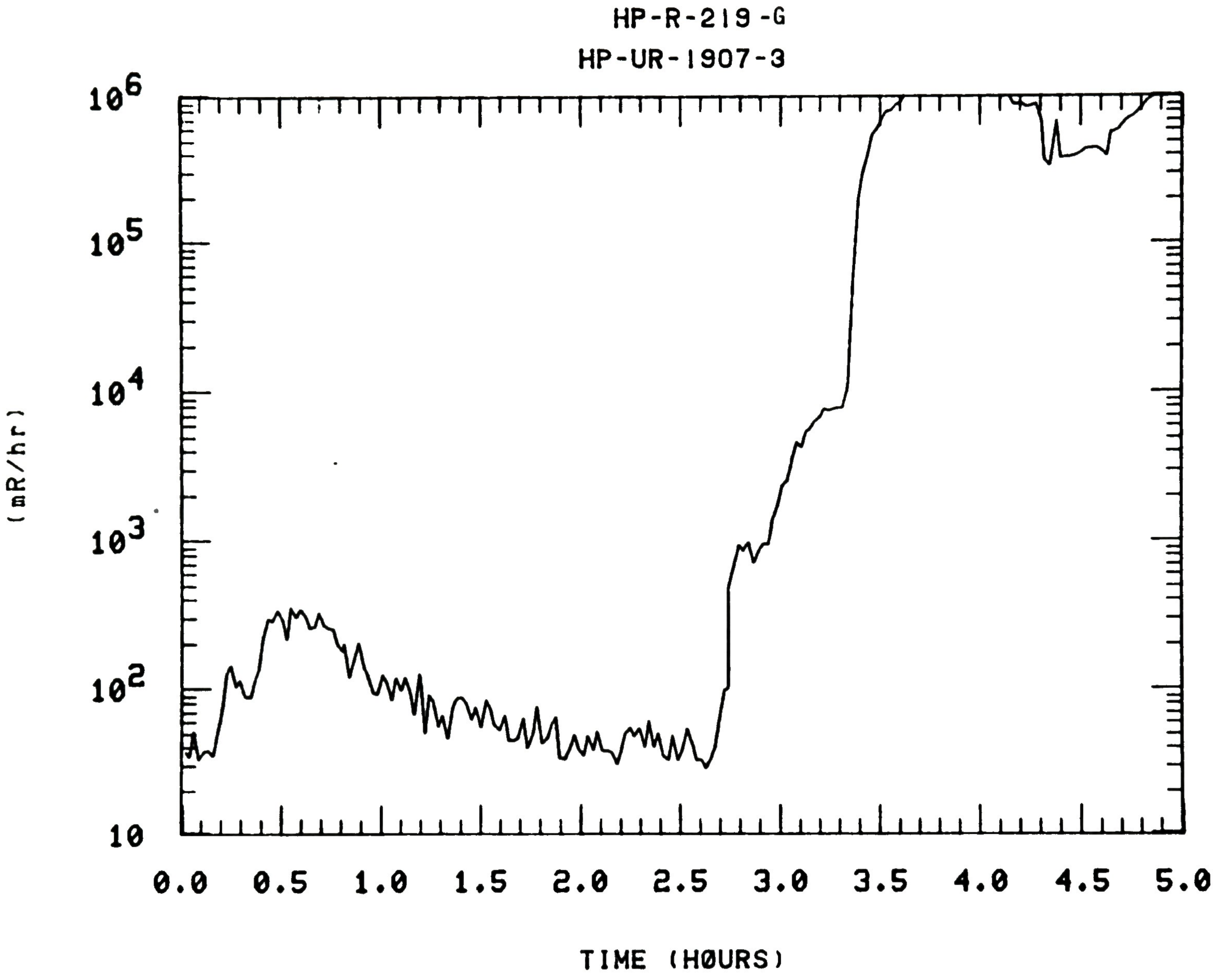


Figure A-26. Station vent.

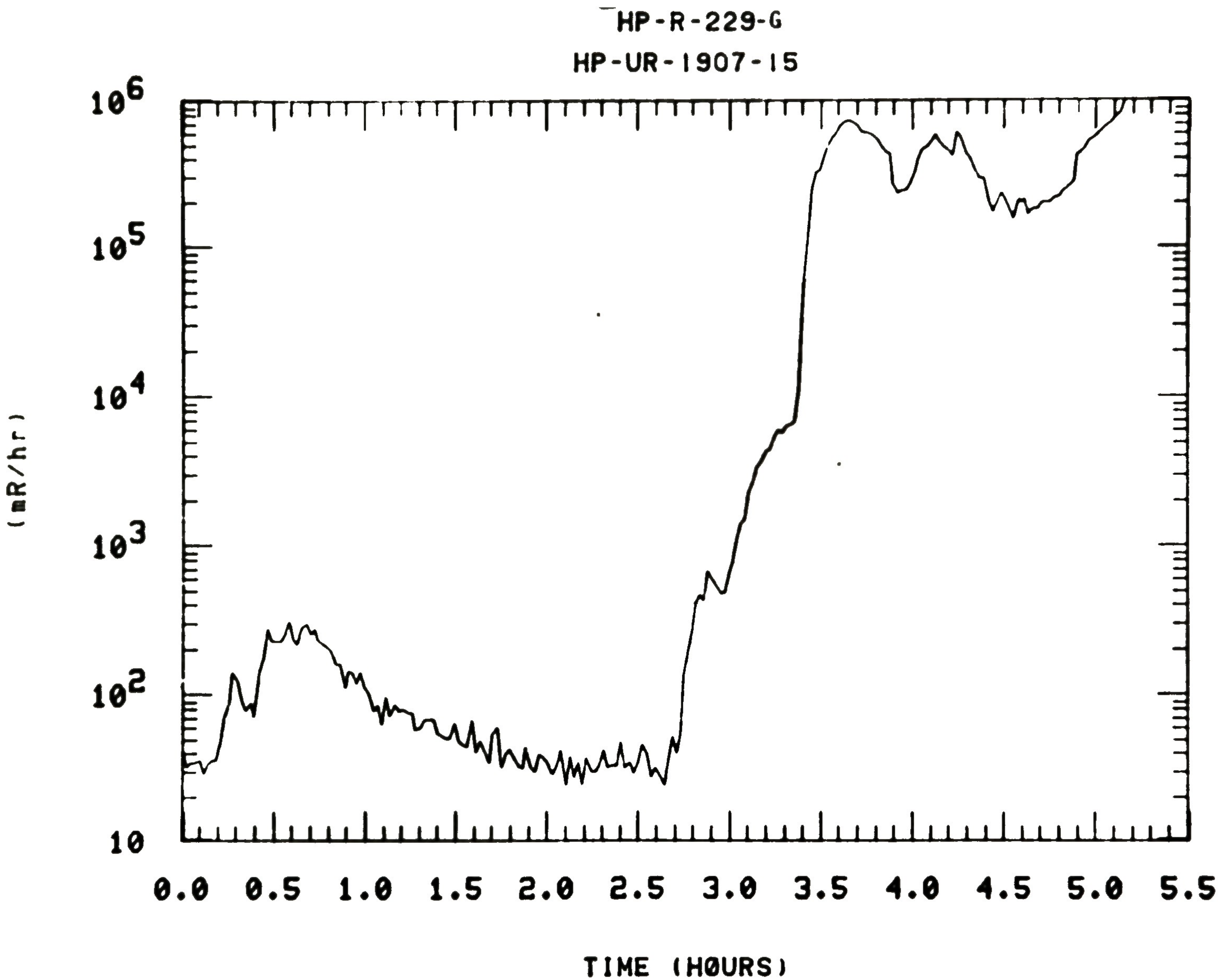


Figure A-27. Hydrogen purge.

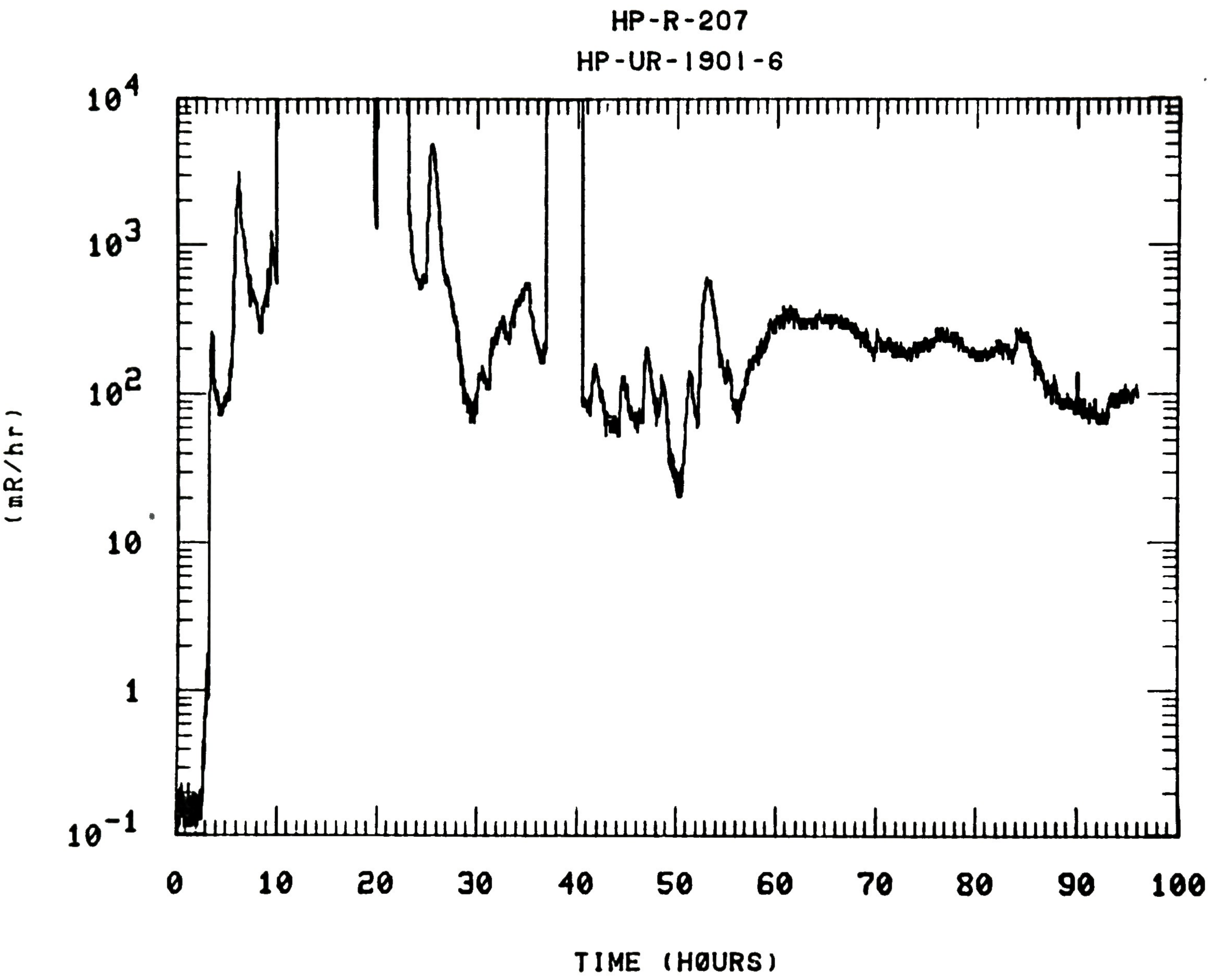


Figure A-28. Intermediate cooling pump area.